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Selfishness and Service

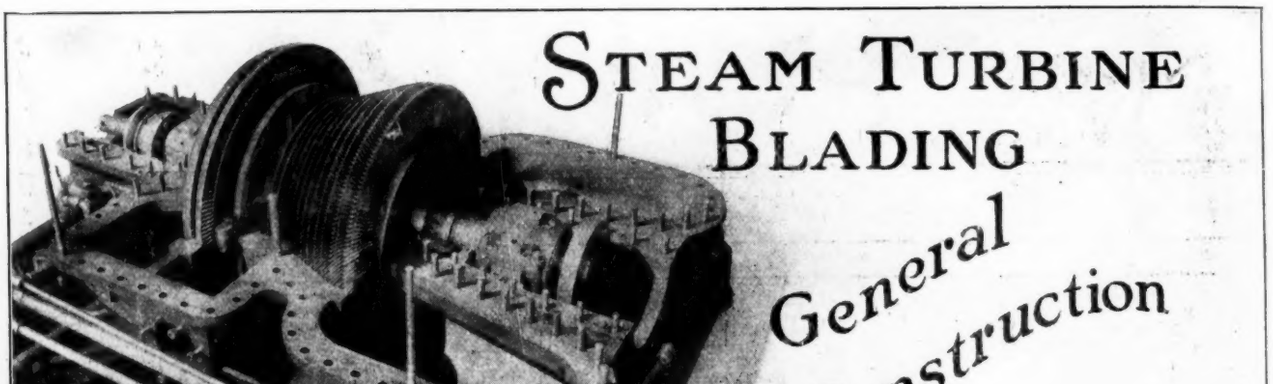
THERE is a school of philosophy that maintains that selfishness is the mainspring of human activity. John Hobbs says:

> When a man deliberates whether he shall do a thing or not do it .... he does nothing else but consider whether it is better for *himself* to do it or not to do it.

Whether there be such a thing as pure altruism, as self-sacrifice free from any thought of personal advantage, or whether the mother who sacrifices her raiment or her last bit of food to her shivering or hungry child, does so because the child's enjoyment of them gives her more pleasure or spares her more pain than would her own use of them, may be only conjuring with terms.

But if self-advantage is the mainspring, give us the man whose self-seeking is liberal enough to include his fellow man; who is broad enough to labor for the common good and be satisfied with his share in the common harvest; and whose happiness would be impaired rather than enhanced by the excuse of an exaggerated self-interest, nurtured at the unrequited expense of others.

F. R. Low



STEAM TURBINE BLADING

General Construction

This is the first of a series of articles describing commercial turbine blading, which tells how to distinguish impulse from reaction types, why some impulse blades are unsymmetrical and what general conditions govern blading materials. De Laval, Ridgway, Kerr and General Electric blading are described and illustrated. Subsequent articles deal with other types of impulse blades, Westinghouse and the Allis-Chalmers reaction type blading with recent improvements.

MOVING blades convert energy contained in the steam into power for driving the rotor. This energy exists in the form of speed or velocity. Strength necessary to receive and transmit the driving thrust, however, is one of the least important factors, since conditions arising from rotative speed and the presence of steam—centrifugal force, vibration, corrosive and erosive action—represent the chief obstacles to contend with. Stationary vanes are not subjected to centrifugal strain, and are less affected by vibration, and present less of a problem than moving blades.

Material for turbine blading has been developed to withstand the action of oxygen or other corrosive elements in the steam, hardness to prevent erosion by drops of water or solid particles, the requisite strength necessary to resist centrifugal force, and adaptability to manufacturing processes. In small or medium-sized machines strength ordinarily is not so important a factor as in large turbines; for the capacity of a large turbine unit is often limited by the strength of the material composing the low-pressure blades. In other words, the length of the blade, and therefore the capacity of the last row, is limited by the ability to withstand centrifugal force, with the additional strain imposed by steam thrust and vibration. Various bronzes or similar alloys of copper, nickel, etc., are used for the blading where strength is not the limiting factor. Steels containing elements such as nickel for the purpose of limiting corrosion, are used where greatest strength is required, as well as Monel metal, a natural alloy consisting of approximately 72 per cent nickel, 1½ per cent iron and 26½ per cent copper.

Turbine blades travel at speeds varying from approximately 200 to 1,200 ft. per sec., depending on the size of the unit and type of blade. Low-pressure vanes are subjected ordinarily to greater stresses than those for high-pressure conditions. Materials used for blading have an ultimate strength of 70,000 to 90,000 lb. per sq.in. for extreme cases, and elastic limits, which are more important, of 46,000 to 60,000, while alloys for less severe conditions have been developed for anti-corrosive and other qualities rather than strength. Factors of safety at the point of tripping the emergency governor vary from 3 to 5 on the ultimate, while those for normal speeds are higher in proportion.

Fastening the stationary turbine blades is simple when compared with the more serious conditions involving moving vanes, where strength and rigidity are vital.

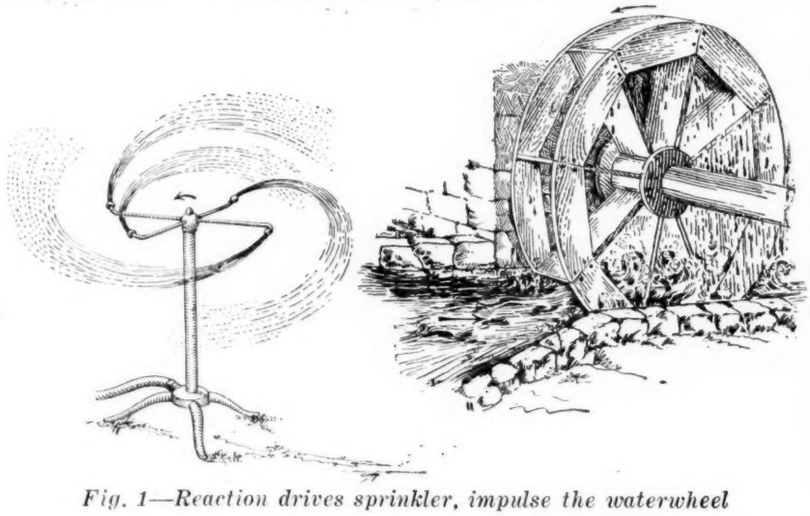


Fig. 1—Reaction drives sprinkler, impulse the waterwheel

Vibration is undesirable in all types of blades, and is guarded against by tying them together with shroud rings, lashing wires passing through the blades or specially rigid methods of mounting. Blades in the larger sizes are often built with a greater cross-section at the root than at the tip, presenting a tapering form. They are in all cases designed so that rubbing which

may take place in the turbine, will not ordinarily cause serious damage

The impulse principle is illustrated at the right in Fig. 1, where the shock or impact of a moving stream of water turns an undershot wheel. This means that the fluid that does the work is supplied at a certain definite speed or velocity, at which it comes in contact with the moving element.

Impulse Blading as Distinguished from Reaction Type

Impulse blading is illustrated in Fig. 2. The nozzle to the left expands steam to a high speed or velocity, which is supplied to the moving blades, where a reversal takes place in the direction of the steam path. This reversal imparts an impulse, tending to drive the blades in the direction of rotation indicated by the arrows. The stage at the left is known as a Curtis type, in which steam is supplied at sufficient speed to travel the two rows of moving blades, a stationary or intermediate row being required in order to reverse the direction suitable for entering the second row. In the stage at *B*, which is known as the Rateau type when used in a multi-stage turbine, steam is supplied only at sufficient speed to pass through one row of moving blades. If the diameters of the wheels are the same in each instance, the steam speed will be approximately half that required for the Curtis stage. If we consider, however, two single-stage turbines, where the entire expansion takes place in a single nozzle from the initial pressure to the exhaust, a two-row Curtis stage will operate at one-half the speed of a single row stage of an equal wheel diameter.

In a symmetrical impulse blade the discharge represents a diverging area, or in other words, the area increases from the center of the turn to the extreme

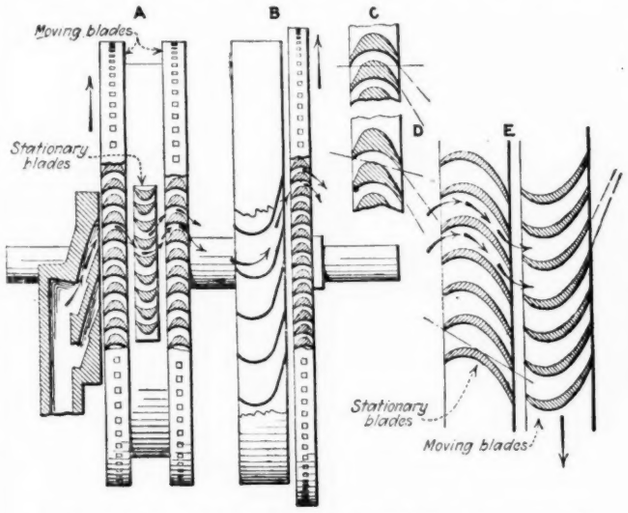


Fig. 2—Impulse stages at A and B as compared with reaction at E

point where the steam leaves. In a reaction turbine this discharge passage converges, or in other words, decreases continually toward the steam exit. The reason for the latter is that this forms a converging nozzle for controlling the expansion of the steam traveling through the blades, while in the former case no expansion takes place in the vanes.

Unsymmetrical impulse blades, as hereinafter described, may for various reasons converge to some extent toward the discharge. In this case they could not of themselves be distinguished from reaction type. The true test, by simple inspection, therefore, is whether steam is supplied to the moving vanes by expanding in a few nozzles or many stationary vanes. In pure impulse blades or impulse vanes with some reaction

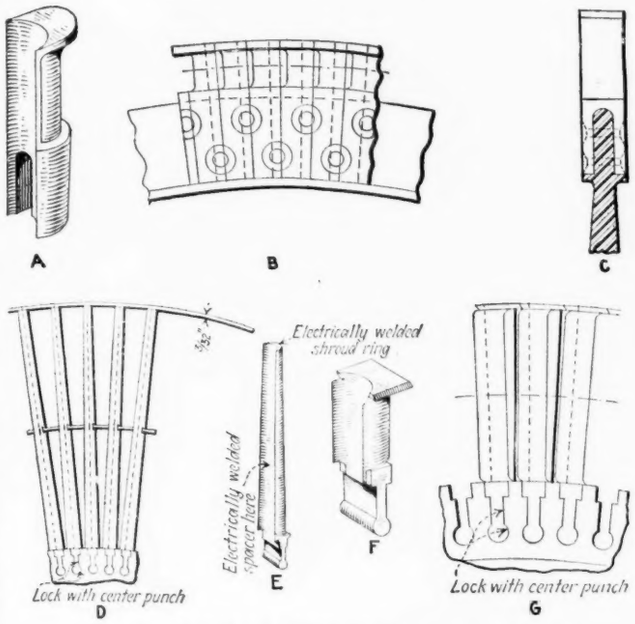


Fig. 3—Moving blades of Ridgway Dynamo and Engine Co.

Smaller sizes are riveted, *A*, *B*, *C*, while larger ones, *D*, *E* and *F*, are bulb-shank type fastened by riveting the ends of the shank. These are tapered from base to tip, with electrically welded shroud ring.

present, steam is supplied by one or more stationary nozzles to the moving blades. Nozzles are contained in a steam chest or diaphragm. In a reaction type turbine stationary blades shaped like moving blades, supply steam directly to moving blades, as described later in connection with *E*, Fig. 2.

Symmetrical and Unsymmetrical Impulse Blades

Symmetrical impulse blades are indicated at *C*, Fig. 2, in which the entrance and discharge areas have the same angle to the disk. At *D* is shown an unsymmetrical impulse blade in which the discharge side makes a sharper angle with the disk. When a jet of steam passes through a moving impulse blade, there is a comparatively large loss in velocity, due to the friction of the blading; this may be 25 per cent in the case of the small machine or one-half to one-third this amount in a larger, carefully designed unit.

As a matter of fact, some reaction is usually present in impulse blades because many designers believe that a certain slight degree of reaction helps the efficiency. It is desirable to keep the exit angle of the buckets as small as possible in order to reduce the loss represented by the absolute velocity or speed of the steam as it leaves the bucket.

In order to reduce the exit angle, the blade is frequently made higher on the exit side; that is, there is a flare at top and bottom of the bucket, while the width of the passage between the buckets actually becomes narrower toward the outlet. In single velocity stages it is quite general to have an inlet area greater than the

theoretical requirement, since the buckets overlap the discharge openings of the nozzles.

It is the relation between the area of the outlet of the bucket to the area at the outlet of the nozzle which largely determines whether or not there will be reaction. With multiple velocity stages it is nearly always difficult to avoid some reaction. The length of bucket required for pure impulse action in the last stage often becomes impossible unless the exit angle is increased to the point where the leaving loss is too great. The more reaction there is, the more important it becomes to have close clearances over the ends of the buckets and to use full admission rather than partial admission.

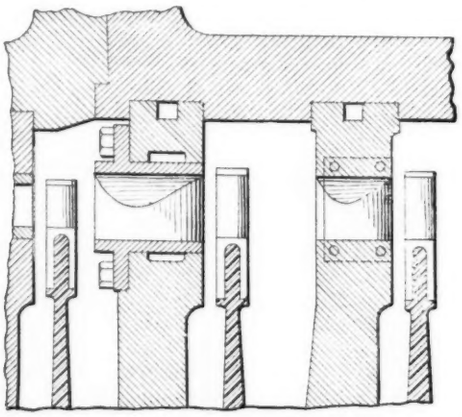


Fig. 4—Rateau stages of a Ridgway turbine

In multi-stage turbines designed for maximum economy, we would therefore expect to see unsymmetrical impulse blades; both types produce a slight thrust toward the exhaust, easily carried by the ordinary thrust bearing. This may be due either to reaction if present, or to axial components of entering and discharge steam.

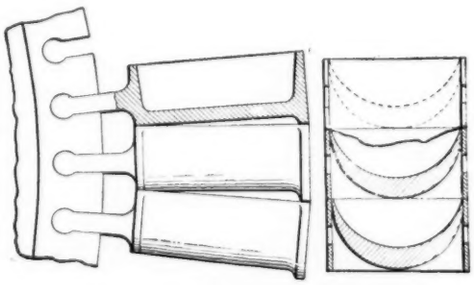


Fig. 5—De Laval type blades

Each blade is a complete unit, containing a shroud ring element and a bulb shank for fastening.

Reaction-Type Blading

Returning to Fig. 1, the lawn sprinkler is driven by reaction. The fact that this emits water which does not expand is somewhat misleading. If we consider that instead of water, compressed air or steam is supplied, which expands in the nozzle only, and the supplying hollow arms contain large passages so that the fluid travels at a low velocity, practically negligible, we have a pure reaction driven machine. The expansion takes place in the moving parts only, as in contrast to the true impulse machine, in which expansion takes place only in the stationary parts. A pinwheel is also a true reaction machine, which is driven by expansion of gas in the moving parts.

At *E*, Fig. 2, are shown cross-sections of reaction blading. Reaction turbines have been built similarly to Fig. 1, which supply steam from a revolving arm mounted on a hollow shaft, representing a pure reaction machine, but this type has not proved satisfactory commercially, and instead steam is supplied in most reaction-type turbines by a set of stationary blades, in which it expands, giving sufficient velocity to enter the moving blades. Expansion takes place through the moving blades, also, so that the lower pressure at the discharge tends to impel in the direction of rotation.

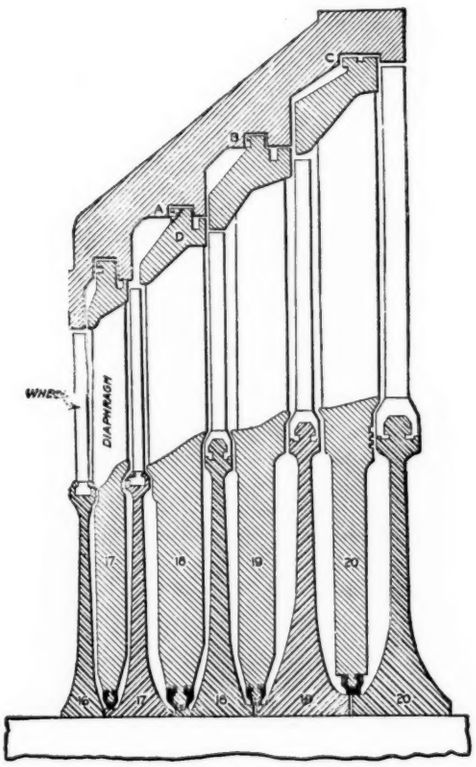


Fig. 6—Low-pressure blade fastening in large General Electric turbines

Why Reaction Blades Converge

The reason that the revolving and stationary blades are converging nozzles is similar to the reason that a multi-stage impulse turbine containing, say, half a dozen stages, uses converging impulse nozzles. If steam at 100 lb. absolute is expanded to 40 lb. or 20 lb. or any pressure lower than one-half that of the steam supplied, a diverging nozzle is necessary. If steam at 100 lb. absolute is expanded to 60 lb. or 75 lb., a converging nozzle is necessary. In other words, generally speaking, converging nozzles expand to about one-half the original pressure or more than one-half the original pressure, while diverging nozzles expand to a pressure lower than one-half of the original. A nozzle with parallel sides would be required to discharge at about 0.58 times entering pressure. A six-stage impulse turbine would contain six different nozzles, so that each expansion, or at least the later stages, must be expanded to a pressure greater than 58 per cent of that supplied to the nozzle, requiring a converging type. Reaction tur-

bines contain a comparatively large number of rows of blades, in each of which steam expands. There is, therefore, a large number of expansions, each of which is only to a pressure slightly less than that supplied, therefore requiring converging nozzles throughout.

Impulse turbines usually have shroud rings, riveted or brazed over the blades, as indicated at *A* and *B*, Fig.

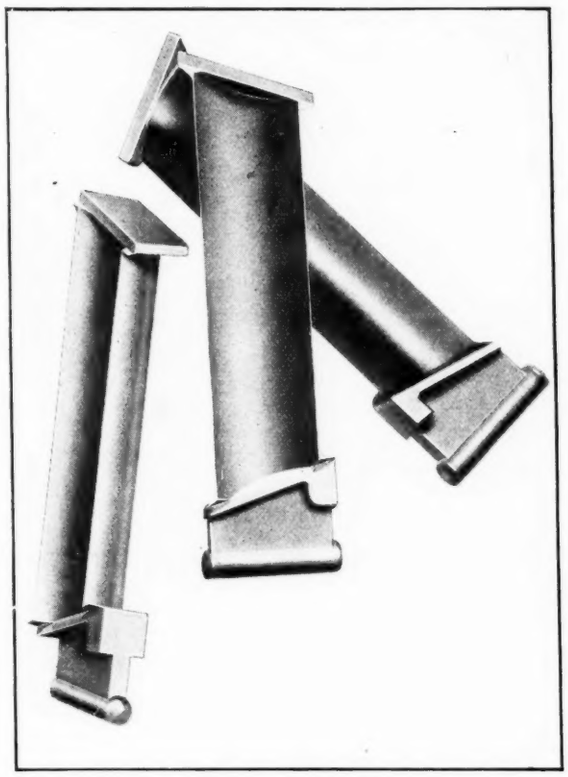


Fig. 7—Kerr type moving blades

2, while one of the best known reaction types of turbine does not contain a shroud ring, and yet another well-known type is equipped with shroud rings. These will be described in detail in forthcoming articles.

De Laval, Kerr, Ridgway and General Electric Types of Blades

The original De Laval high speed single-stage turbine used steam at the highest velocities obtainable by expansion in a single nozzle from boiler pressure to that of the condenser. The revolving blading, therefore, was subject to extreme centrifugal force and steam conditions. The general design of buckets shown in Fig. 5 is due to Gustaf De Laval, who was the first to obtain general commercial success with an impulse-type turbine, his earliest patent being in 1889. After considerable experimenting the De Laval Steam Turbine Co., in this country, has continued to use this design of blade. Even though their machines operate with low steam and bucket velocities, this fastening is used, which is considered to represent the strongest known bucket fastening which permits renewal of a single blade at a time. Drop-forged buckets are held in place by bulb shanks which are pressed into suitable slots in the wheel rim. It will be noticed that each blade is a separate unit which may be renewed without disturbing the others on the wheel, and contains a protective surface or shroud ring section at the top, which just touches a similar surface of the bucket on either side, so that a complete shroud ring is thus composed of these shroud elements.

Nickel steel is used in the single-stage turbines, while for the multi-stage machines Monel metal or nickel bronze is employed, which is satisfactory for 600 deg. F. or higher. The drop-forging process produces a smooth skin on the bucket, which is superior to machined surfaces for resisting wear and corrosion.

The stationary blades are held in slots by dovetails. These are necessary when Curtis stages are used. Each section of stationary blades, consisting of a holder with blades assembled, as in Fig. 8, is easily bolted to the machine and easily changed. Dovetail slots in the holders are riveted at each end, in order to prevent the blades from working out.

The majority of the buckets manufactured by the Ridgway Dynamo & Engine Co. are of the unit type, where each contains the outside protective surface, or in other words, the shroud ring element, but they are attached to the rim of the wheel by means of rivets, as shown in Fig. 3, *A* and *B*. These blades are made from extruded stock and in machining, the inside portion of

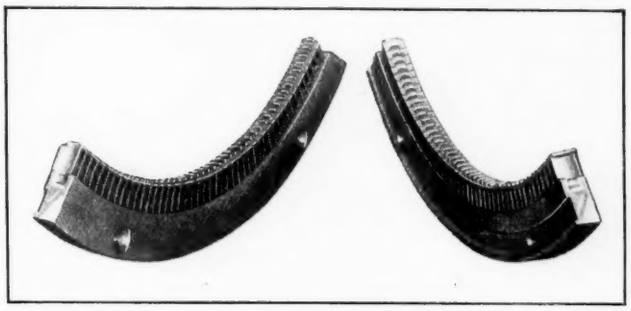


Fig. 8—De Laval stationary vanes

Stationary vanes are dovetailed into grooves of the holding pieces; a shroud ring element is riveted to the tips and the blade at each end of the slot is fastened by peening the holder.

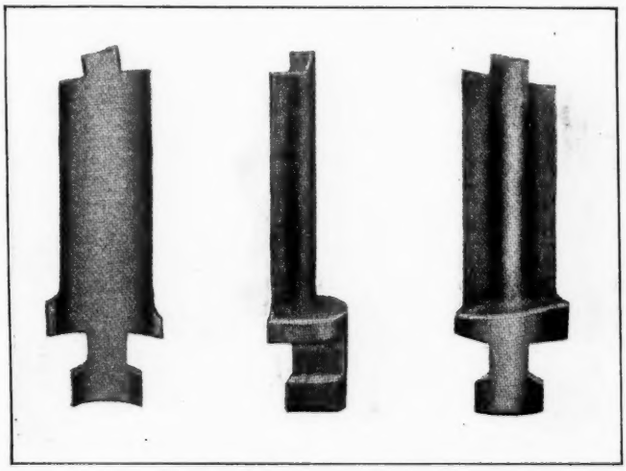


Fig. 9—Each shank is proportioned to give correct blade spacing

the bucket, or in other words, the hollow side, which causes the curvature of the steam jet, is not touched, so that the surface, hardened due to extruding through the die, remains for contact with the steam. The back of each bucket is tapered from top to bottom so as to give a radial fit against the adjacent bucket, and the slot for the wheel rim is milled with a special cutter. These are assembled on the wheel rim and drawn up tightly by means of a steel band and then riveted. They are

tested by rotating at 50 per cent overspeed. Nickel steel is used for high superheat where high steam velocities are met with, and high centrifugal forces, such as would be found in speeds greatly exceeding 3,600 r.p.m. These blades may be replaced by renewing the rivets for the new blades. This type is made in lengths up to four inches.

Turbine blades up to 7½ in. long, at 3,600 r.p.m., are of the same type except that bulb-end shanks are employed, as shown in Fig. 3, *D*, *E* and *F*. This type is capable of resisting great centrifugal strains. These are milled from forged rectangular bars, upset on one end to form the shroud section, and are inserted in slots milled in the wheel. This type is used on low-pressure stages, where the length of bucket makes great centrifugal resisting strength necessary. For lengths exceeding 7½ in. at 3,600 r.p.m., a chrome-nickel steel bucket is employed, which is tapered in width and thickness, as shown at *D* and *E*, Fig. 3. These are made from rectangular bar stock, heat-treated, and contain an electrically welded shroud ring as well as intermediate welded spacers to prevent vibration. Monel metal has also proved very satisfactory for high temperatures and velocities.

Fig. 7 shows the drop-forged type of blade used by the Kerr Turbine Co. These are of nickel steel, with bulb shanks riveted in place. The oxidized skin due to forging is especially resistant to wear and corrosion. Stationary blading is dovetailed into special holders.

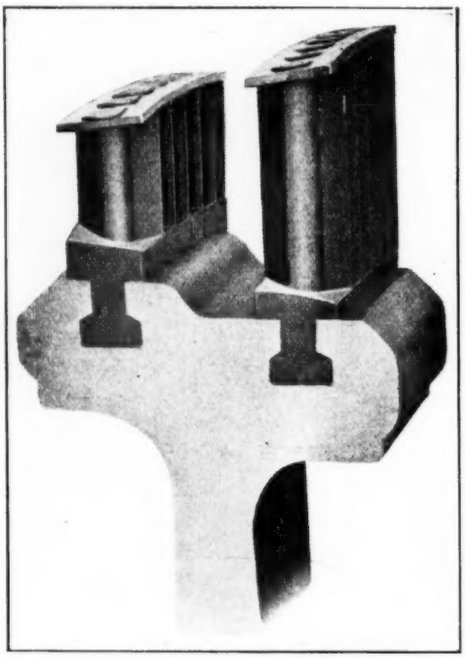


FIG. 10—DOVETAIL FASTENING OF GENERAL ELECTRIC BLADES

Blades employed by the General Electric Co. are fastened by means of dovetail connections, as shown in Fig. 10. The shroud ring is ordinarily riveted on. Fig. 9 shows some of the forged blades. Each is shaped so as to give the right spacing from the blade preceding it. The blades are inserted in the slot, as shown in Fig. 10, by a special opening at the right of the slot. A number of such openings are left around the periphery of the wheel, which are afterward filled with plugs. In the original Curtis turbines blades were cut from solid metal by tools that were moved in a path to produce the curve forming the blade section. This was found to be an extremely ineffective method, which was later replaced by that of making blades of drawn metal or forgings. Separate spacing pieces were used between blades, which were made up from extruded stock. Most blades nowadays are shaped so as to space themselves automatically, so that no separate spacer is required, as shown in Fig. 9. The shrouding is placed on the blades in small sections, instead of a continuous band as used on some machines. Stationary blades are held in holding pieces by means of dovetails, similar to De Laval construction in Fig. 8.

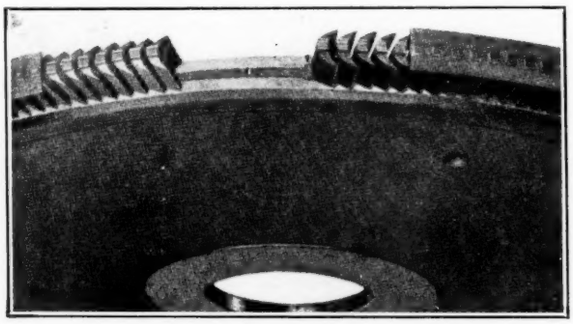


FIG. 11—METHOD OF ASSEMBLING
Dovetail shanks are inserted in opening at the right of the slot This opening is finally closed by inserting a filler and riveting.

Blading in the low-pressure end of a large 20-stage General Electric turbine is shown in Fig. 6. The dovetail construction is the reverse of that in Fig. 10, such as is in general use in large turbines. The active length of the last blade is approximately sixteen inches.

Rubbing of Impulse Blades

Large radial clearances characteristic of impulse blades are indicated in Fig. 4. Rubbing of the shroud rings against the wheel casing never occurs, while the rotating and stationary elements are intact. Rubbing between the blades and nozzles frequently happens when abnormal adjustments or vibration occurs. It can be seen in Fig. 4 that the blade shanks would contact with the diaphragm if the rotating element were moved far enough in one direction. In Fig. 7 it is shown more clearly that the blade is slightly narrower than the shank, so as to prevent actual blade contact to a large extent. This proportion is also true of the General Electric blades, Fig. 9, and practically all impulse turbines. The shroud ring is usually equal to the shank in width, so that the blade itself is ordinarily saved from contact in case rubbing that is not violent should take place.

Corrosion in a boiler is usually due to or accompanied by electrolytic action. Iron and steel are complex elements, and probably differences of potential exist between different parts of the same boiler or between different parts of the plate. Such a condition results in minute currents being set up and causes the wasting of the metal at the points that constitute the positive plates. This action in many cases accounts for the fact that corrosion is not generally uniformly distributed over a boiler or plate, but tends to be localized in particular places, some portion or portions of the plate being attacked while others are free from pitting.

Continuous Power-Plant Testing

How the Efficiency of the Boiler Plant Can Be Found Each Day—Examples of the Necessary Log Data Together with the Simple Process of Making the Calculations

By THEODORE MAYNZ
Engineer, The Cleveland Electric Illuminating Company

IT IS a common impression among engineers that a test of a power plant involves such a mass of equipment and mathematical calculations that only on special occasions can one be conducted. In the larger power plant, such as central stations, this idea no longer exists and it is quite customary to follow a system of finding the plant efficiency each day or, as it is often termed, "continuous testing."

The calculations used in checking power-house operations are simple but, as usually applied, involve considerable time and effort. However, these routine calculations can be simplified so that only a small amount of time is required. This the writer will attempt to do and will take up the boiler room first. While the methods to be shown apply specifically to a large central station, the principles and types of charts can be applied to a plant having but two or three boilers and one or two engines.

In Fig. 1 is shown the boiler-room log of a 250,000-kw. central station, while Fig. 2 is a type of report quite suitable for a plant of 6,000 kw. or under. The former, a very detailed sheet, is made up daily and requires the services of one man. Fig. 2 is a weekly and monthly report and calls for but little work; the chief engineer can easily make the calculations without interfering with his other duties.

The most important measurements in a power plant are the fuel input, the power output and the feed water. Little need be said about the first two, but the third is often neglected or measured incorrectly. Only the best type of meters should be used, and these should be checked every thirty days and overhauled completely every ninety days.

It has been the writer's experience that, owing to mechanical construction and to human errors, it is far more accurate to planimeter the chart of feed-water meters than to trust to integrator readings. Using a radial planimeter, curves may be obtained for the plant meters, and it will require about three minutes to obtain the total water as measured by the meters. The curve for temperature correction, such as shown in Fig. 3, may be obtained from the meter manufacturers or can be calculated from the density-temperature tables for water. Applying the temperature correction as obtained from the average temperature and the curve shown will give the actual water for the 24 hours or for the shift.

To determine the boiler efficiency, after the necessary

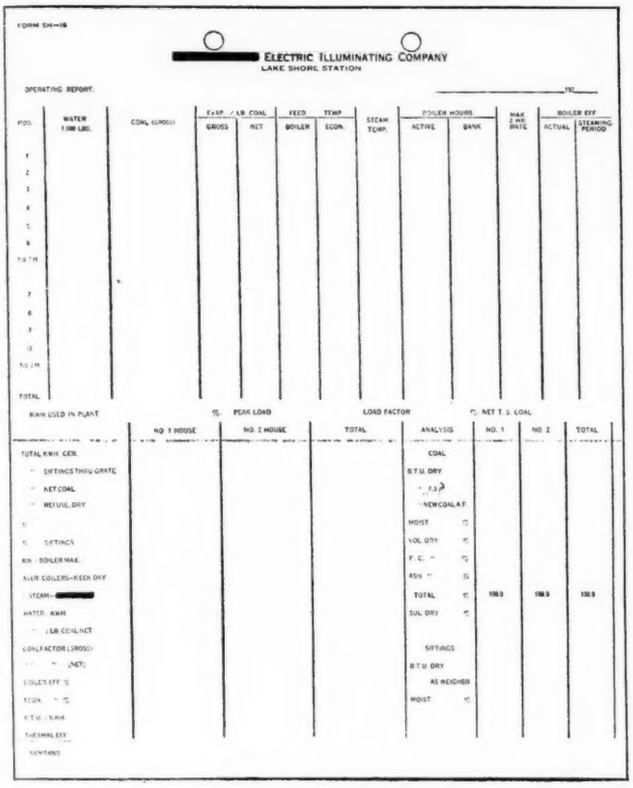
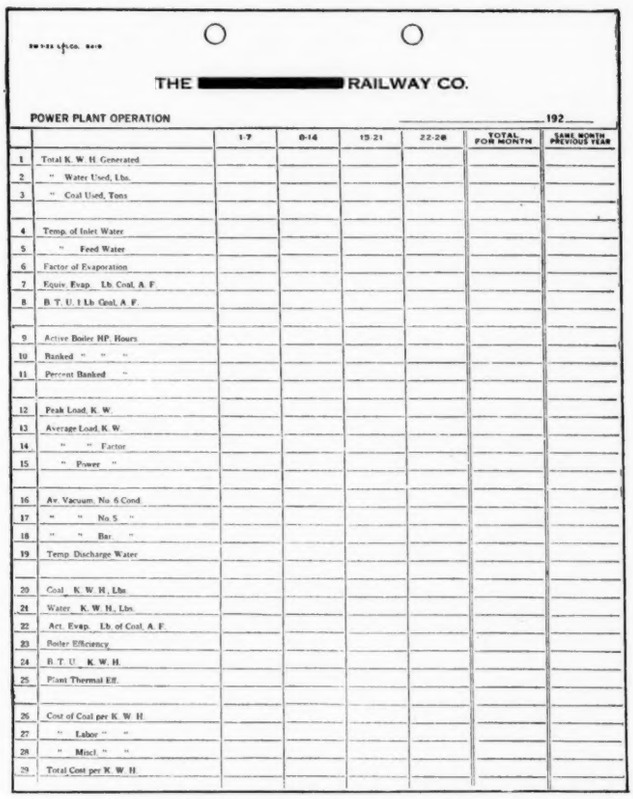


Fig. 1—Log for large plant


THE [redacted] RAILWAY CO.
POWER PLANT OPERATION
192
1-7
8-14
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22-28
TOTAL FOR MONTH
SAME MONTH PREVIOUS YEAR
1 Total K. W. H. Generated
2 " Water Used, Lbs.
3 " Coal Used, Tons
4 Temp. of Inlet Water
5 " Feed Water
6 Factor of Evaporation
7 Equiv. Evap. Lb. Coal, A. F.
8 B. T. U. 1 Lb. Coal, A. F.
9 Active Boiler HP. Hours
10 Banked " " "
11 Percent Banked "
12 Peak Load, K. W.
13 Average Load, K. W.
14 " " Factor
15 " Power "
16 Av. Vacuum, No. 6 Cond.
17 " " No. 5 "
18 " " Bar. "
19 Temp. Discharge Water
20 Coal, K. W. H., Lbs.
21 Water, K. W. H., Lbs.
22 Act. Evap., Lb. of Coal, A. F.
23 Boiler Efficiency
24 B. T. U., K. W. H.
25 Plant Thermal Eff.
26 Cost of Coal per K. W. H.
27 " Labor " "
28 " Misel. " "
29 Total Cost per K. W. H.

Fig. 2—Weekly log for small plants

average quantities of water, coal, pressure and temperatures have been obtained, involves the use of steam tables and fairly long calculations. To avoid this trouble, the boiler-efficiency charts shown in Figs. 4 and 5 were devised and after a test of over three years' service proved to be the quickest and simplest of methods. Although they look quite intricate, their use is simple and their construction not difficult, because all lines except the pressure lines are straight.

The chart in Fig. 5 takes care of practically all boiler conditions, as it has a range of from 100 lb. to 350 lb.

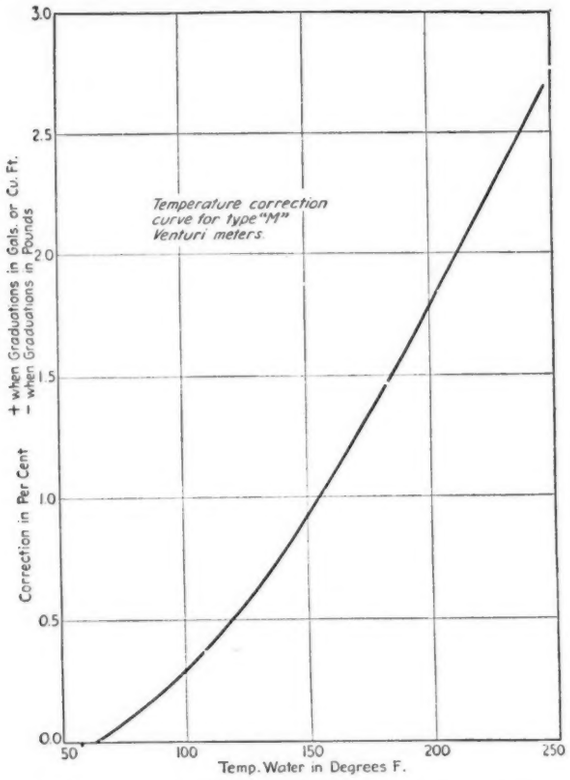


Fig. 3—Feed-water temperature correction

pressure and from 0 to 400 deg. superheat and takes care of from 50 to 90 per cent boiler efficiency. For use in power stations it is advisable to enlarge the scale, using only that portion which is applicable to the plant. Such a chart is shown in Fig. 4, this being a special chart for a plant operating at 150-lb. gage saturated steam and from 130 to 212 deg. feed-water temperature.

Following the lines on the chart in Fig. 5, the boiler efficiency is obtained for the following conditions:

Steam temperature, deg. superheat	150
Steam pressure, lb. abs.	250
Feed temperature, deg. F.	210
Evaporation per lb. of coal (either dry or as fired), lb.	7.8
B.t.u. per lb. of coal (either dry or as fired)	12,000
Boiler efficiency, per cent	72.25
Calculated efficiency (using M. & D. tables), per cent	72.20

The problem outlined on the chart in Fig. 4 shows the following conditions on the chart in the order used:

Feed temperature, deg. F.	165
Moisture, at 150 lb. gage, per cent	1.0
Evaporation per lb. coal lb. (dried or as fired)	8.3
B.t.u. per lb. of coal (dried or as fired)	12,800
Boiler efficiency, per cent	68.4

As a check, the efficiency may be found by first solving for the total heat at 150-lb. gage and 1 per cent moisture by the equation $H = h + xr$, or $H = 338.05 + 0.99\ (856.92) = 1{,}186.4$, where h is the heat of the liquid, x equals quality of the steam and r the latent heat of vaporization.

The calculated efficiency is then

$$\frac{(1186.5 - 132.9) \times 8.3}{12{,}800} = 68.32 \text{ per cent.}$$

It is often desirable to obtain the steaming efficiency of boilers as well as the over-all efficiency. To determine this factor, a careful log of the banking hours and the number of times a boiler is banked and new fires started, should be kept and the coal used for such operation estimated and deducted from the total coal fired.

$$\text{Lb. coal} = a + bx$$

where

a = Pounds of coal wasted in coming onto and off from a bank;

b = Pounds of coal used per hour while banked;

x = Number of hours of duration of bank.

These quantities may be determined fairly accurately

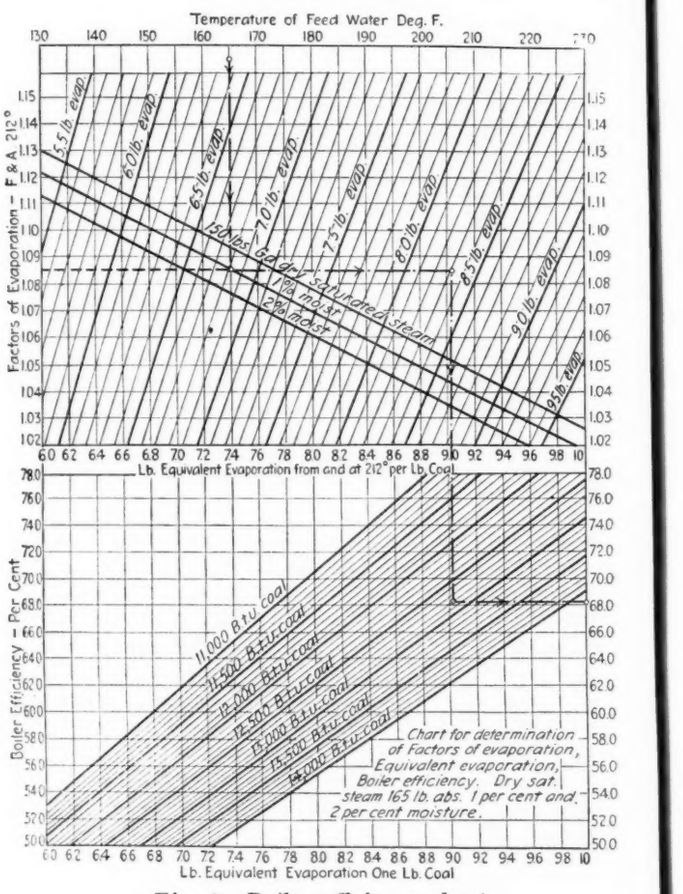

Temperature of Feed Water Deg. F.
Factors of Evaporation – F. & A. 212°
5.5 lb. evap.
6.0 lb. evap.
6.5 lb. evap.
7.0 lb. evap.
7.5 lb. evap.
8.0 lb. evap.
8.5 lb. evap.
9.0 lb. evap.
9.5 lb. evap.
150 lbs. Gage dry saturated steam
1% moist.
2% moist.
Lb. Equivalent Evaporation from and at 212° per Lb. Coal
Boiler Efficiency – Per Cent
11,000 B.t.u. coal
11,500 B.t.u. coal
12,000 B.t.u. coal
12,500 B.t.u. coal
13,000 B.t.u. coal
13,500 B.t.u. coal
14,000 B.t.u. coal
Chart for determination of Factors of evaporation, Equivalent evaporation, Boiler efficiency. Dry sat. steam 165 lb. abs. 1 per cent and 2 per cent moisture.
Lb. Equivalent Evaporation One Lb. Coal

Fig. 4—Boiler-efficiency chart

by test or estimated from the type and size of stoker.

For chain grates, natural draft, with tight dampers and careful banking operation,

a = 25 to 30 lb. per sq.ft. of grate surface,

b = 0.4 to 0.5 lb. per sq.ft. of grate surface.

For forced-draft chain grates,

a = 12 to 15 lb. per sq.ft. of grate,

b = 0.3 to 0.4 lb. per sq.ft. of grate.

For underfeed stokers,

a = 10 to 12 lb. per sq.in. of grate,

b = 0.2 to 0.3 lb. per sq.ft. of grate.

New fires require approximately 30 to 35 lb. of coal per square foot of grate for natural draft chain-grates.

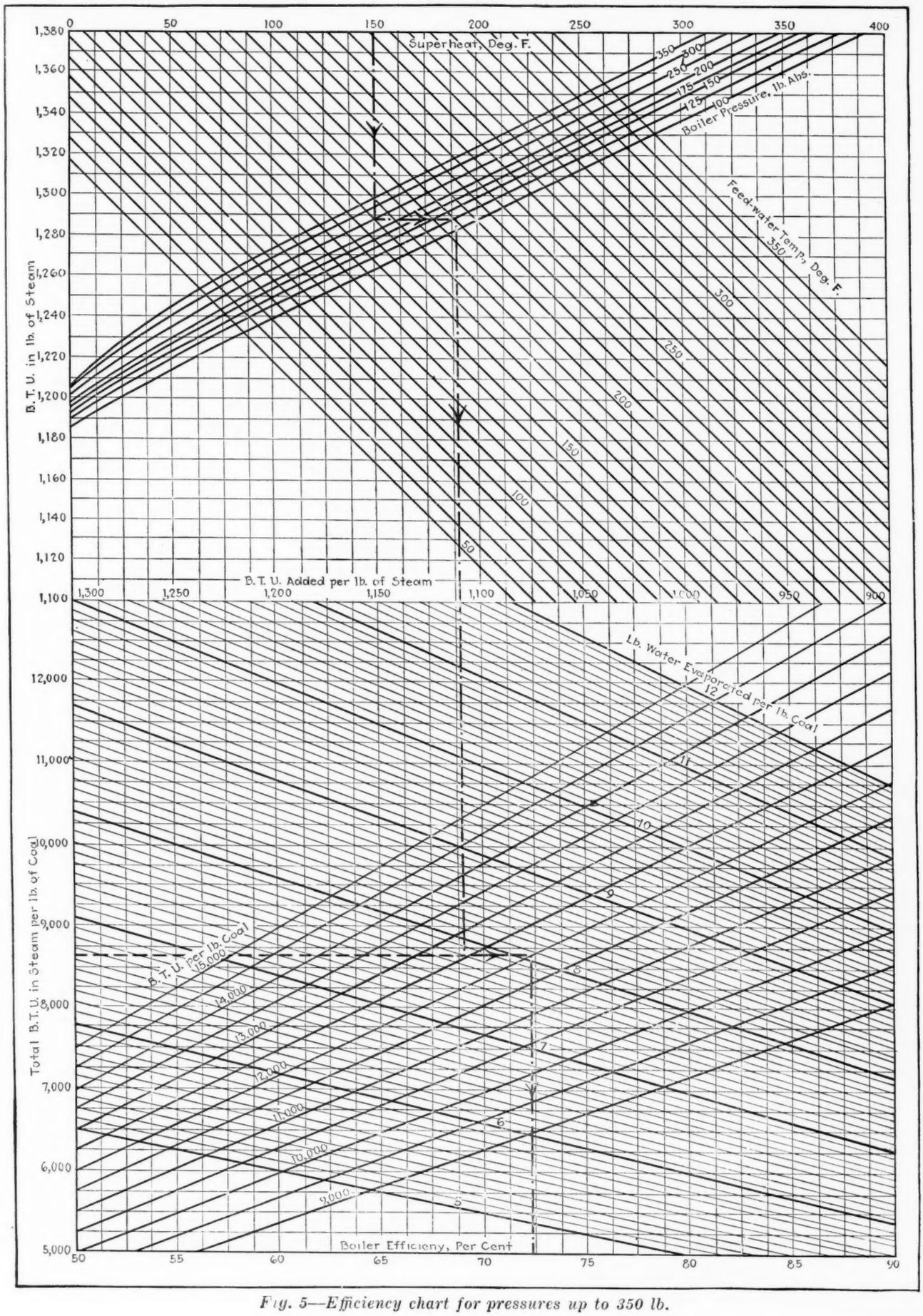

Superheat, Deg. F.
Boiler Pressure, lb. Abs.
Feed-water Temp., Deg. F.
B. T. U. in lb. of Steam
B. T. U. Added per lb. of Steam
Lb. Water Evaporated per lb. Coal
B. T. U. per lb. Coal (15,000)
Total B. T. U. in Steam per lb. of Coal
Boiler Efficiency, Per Cent

Fig. 5—Efficiency chart for pressures up to 350 lb.

15 to 20 lb. for forced-draft chain-grates, and 12 to 15 lb. for underfeed stokers.

Where the boiler-feed water is mostly condensate and only 3 to 5 per cent makeup used, the boiler is blown down only once in 24 hours or less, and therefore the water wasted in blowdowns is less than ¼ per cent of the total. However, where there are bad water conditions, often boilers are blown down every four hours and the water loss is considerable, thereby making the apparent evaporation considerably greater than the actual and the boiler efficiency too high. Under such conditions a record of the number of times the boilers are blown down should be kept and the water wasted per blowdown estimated and deducted from the total water. A rough calibration of the water in the boiler drum at its center per inch of blowdown will give sufficiently accurate results.

In plants having stokers that sift coal and in which the siftings are not immediately refired, but are distributed back into the bunkers and reweighed, the weight and heat value of the siftings must be deducted. This is of particular importance where the coal sampling is taken at the stoker hopper. The method of handling this must be suited to the conditions of the plant, but must be taken into account, owing to the fact that the heat of siftings will have a value of 8,000 to 9,000 B.t.u. when the coal has a heat value of 12,000 to 13,000 B.t.u.

[This article, which is the first of three on continuous power-plant testing, covers the general performance reports for a boiler room of any size; the engine-room calculations will be discussed in the next article.—Editor.]

Upflow Valve Scavenging of Two-Stroke-Cycle Engines

By Robertson Matthews

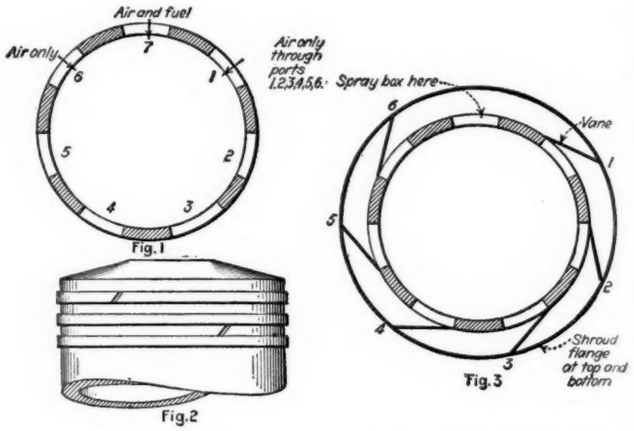
The attempt to obtain speeds of 1,400 to 1,800 r.p.m. from two-stroke-cycle oil engines discloses formidable problems. These are not confined to design alone and are not all apparent to one accustomed to the ways of slow-running engines. Advances, however, in the development of the high-speed engine are of interest to all those working with internal-combustion engines, since many of the problems of slower engines are advanced at the same time.

One appeal that the low-speed two-stroke-cycle engine has to the engineer is the possible absence of valves in the cylinder head. With high speed the valve problem returns. Sweeping the spent gases out of the cylinder without a change in direction of air flow at high r.p.m. is an aid to effective scavenging. Accepting the valves in the head as a necessary evil in obtaining straight flow during scavenging, the following questions arise: Shall the engine be designed to exhaust through the valves at the top of the cylinder or through ports at the bottom? Shall the air be brought in at the bottom of the cylinder or at the top?

Obtaining Air and Fuel Mixing

An important consideration is the influence of the direction of air flow in effecting thorough and speedy mixing of fuel and air. This leads to the consideration of the application of an external injection system; that is, one having the injection nozzle discharge into the air stream instead of into the cylinder proper or into an associated pre-combustion chamber. Neither the carburetor with spark ignition nor solid injection with compression ignition meet requirements for a high-speed two-stroke-cycle engine.

The familiar two-stroke-cycle high-speed engine operating around 1,000 r.p.m. uses a light carbureted fuel.



Figs. 1 to 3—Arrangement of air ports and piston

It scavenges with the air-fuel mixture and wastes fuel during scavenging in the most direct manner. There is a further waste of fuel in like manner but from a cause less obvious. The amount of fuel in the cylinder at the time of ignition depends upon the carrying capacity of the air and the facilities provided for letting the fuel flow in synchronism with the air. At high revolutions any fuel lagging in velocity behind the air or unable to make as rapid a turn as air in an air passage, is liable to be arrested in its flow long enough for the ports or valves to be closed before the fuel reaches the cylinder. As a consequence this portion of fuel goes out with the scavenging at the beginning of the next cycle.

Solid-Injection for High Speeds

From the good showing of economy that the two-stroke-cycle Diesel makes, it would seem judicious to apply an injection method to the high-speed engine. During present-day difficulties with high maximum pressures it seems advantageous to have a transition type using solid injection yet retaining spark ignition. From the purely mechanical side solid injection for engines running at speeds of 1,800 r.p.m. either on the four-stroke or the two-stroke cycle, is feasible. The difficulties of metering the quantity of fuel required in the cylinder of an engine running at that speed have been overemphasized. The difficulties of getting a combustible mixture and efficient combustion in the time available is another matter, especially if high mean effective pressures are desired.

With low compression and spark ignition there is only one reason why injection might have to be *internal*, and that is to insure fuel economy. Injection can just as well be external—that is, into the entering air stream—as into the cylinder provided it can be so regulated and timed that the conditions of fuel loss obtaining with mixture scavenging are not repeated. Without the addition of an auxiliary chamber and more valves such timing is difficult of achievement, but it is neces-

sary to the successful attainment of a satisfactory mean effective pressure and economy.

Injection, vaporization, mixing and combustion cannot occur all at one time and instantaneously. Each action or process takes time. Furthermore, liquids do not burn although vapors do. External injection provides opportunity for a small portion of additional time for vaporizing and for aiding mixing. Since the distance traveled toward the air ports by the air charge (other than the scavenging air) during one cycle cannot be far, the spray nozzle cannot be placed a random distance from the inlet ports, nor can the spray be allowed an entirely free path or scavenging losses will occur.

External Mixing

The logical course is to place a special duct or spray box in front of one port. This insures a direct path for the spray. With little space available for the travel of the spray, yet with as long a time as possible desired for contact between air and fuel, the spray can be shot toward the oncoming air. In reversing the direction of spray flow, not only is a longer interval made available, but more scouring and mixing occurs between air and fuel. These difficulties of obtaining such a degree of vaporization and mixing as are essential to efficient combustion seem to increase in much greater proportion than the r.p.m.

With external injection and with the air entering at the bottom of the cylinder the fuel entering with the last portion of air is brought close to a source of heat early in the compression stroke. Meanwhile the piston-head temperature is benefitted by the heat thus abstracted.

The following experiences tend to reveal the benefit to piston-head temperature control that may be obtained from the proper application of air streams entering at the bottom of the cylinder. Fig. 1 represents a section of cylinder 5 in. in diameter. There are seven ports and seven bridges of equal width. The head of the piston is somewhat domed as in Fig. 2. This combination of ports and domed piston head lets the air impinge and concentrate upon the hot center of the piston head. With the fuel entering with this air, brake mean effective pressures equal to the best Diesel practice were obtained at over 1,400 r.p.m.

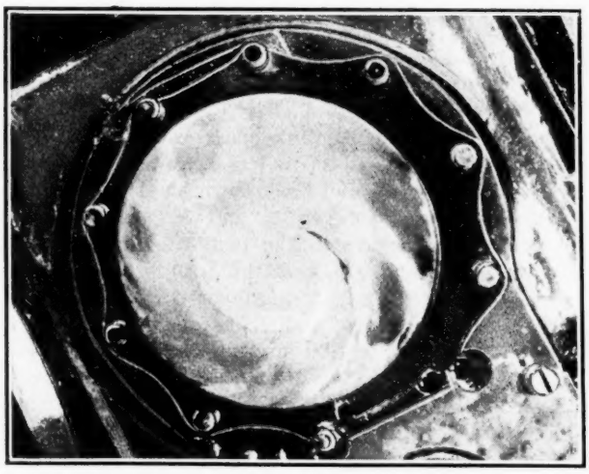


Fig. 4—Air currents form spirals on piston crown

For reasons yet to be proved of value the entrances to the ports were fitted with vanes as indicated in Fig. 3. Owing to lack of space in the air box these vanes had to be set at a smaller angle than would give the desired cross-section of opening normal to the vane. This cut down the quantity of air flow and at the time the air pressure used was only half its former value. However, the quantity of fuel was reduced one-quarter and the brake mean effective pressure obtained was under one-half that with the clear port passages. After a few brief runs of not over four minutes each, a hole was burned through the center of the piston. Attributing this to the tangential spinning of the air, two vanes were removed. With a new piston of the same design the engine was then operated under former conditions of fuel quantity, load and jacket-water temperature, but with a somewhat less quantity of air than when the piston was burnt. After several short runs and while the engine was still running sweetly at over 1,400 r.p.m. and showing nearly 40 lb. brake mean effective pressure, the ignition battery wire was detached. The engine continued to run sweetly, with the piston acting as a hot plate and with slightly rising brake mean effective pressures.

The photograph, Fig. 4, shows the condition of the piston. Due to a large amount of cylinder oil in the air line, a permanent record was left on the piston head of the path of the air after passing through the vanes. The spirals can be seen terminating at the outside of a circle about one inch in diameter at the center of the piston. With all six vanes directing the air flow, instead of only four as when these spirals were registered, there probably was something of a vortex formed over the center of the piston. The absence of cooling that resulted could account for the hole burnt through the center of the piston head.

Single-Impulse Turbine Drives Coast Guard Cutter

The reliability of the steam-turbine generating equipment is well evidenced by the fact that four Coast Guard cutters of approximately fifteen hundred tons displacement are each equipped with an electric drive, operated by one steam-turbine generator unit.

These are designed for a speed of 16 knots when the main driving motor develops 2,600 shaft horsepower. The driving turbine is an eight-stage Curtis machine, the entire equipment being built by the General Electric Co. This operates at 3,000 r.p.m. with steam at 200 lb. and 50 deg. to 70 deg. superheat. It is direct connected to a two-pole three-phase, alternating-current generator designed to deliver 2,040 kw. at 2,300 volts. The main driving motor is of the synchronous type with a squirrel-cage winding on the revolving field. This has 46 poles designed to deliver 2,600 shaft horsepower at 130 r.p.m. The four-bladed propeller is 13 ft. in diameter.

An account of the Coast Guard cutter "Modoc," with this equipment, together with tests and trials by Captain Q. B. Newman, engineer-in-chief, was read at the thirty-first meeting of the Society of Naval Architects and Marine Engineers, held in New York, Nov. 8 and 9, 1923.

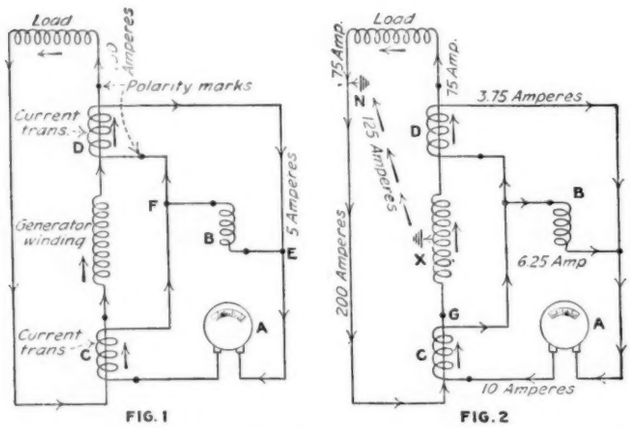
Fire destroys property worth $993 every minute; 85 per cent of all fires are preventable.

Differentially Connected Relays for Protecting Electrical Machinery

By C. M. KING

Explains how differentially connected relays operate when trouble occurs in the equipment they are protecting, and the conditions that cause relay action and the oil switch to open.

THERE are in general two conditions to protect electrical machinery against — overloads which may develop from various causes external from the machine, and trouble within the machine windings. Overload protection will not in general give proper protection to the machine in case of trouble within the windings. Furthermore, if an overload occurs, unless it is of large magnitude and sustained, it is not necessary to disconnect the machine from the line instantaneously. In fact, in some plants, alternating-current generators are



Figs. 1 and 2—Showing how a differentially connected relay operates

connected to the busbars without any overload protection, the operator being depended upon to disconnect the generator from the line in case of a heavy sustained overload that is not cleared by the opening of the line switch. Where this practice can be justified, it saves unnecessary interruptions to service.

If trouble develops within the machine, the quicker it can be disconnected from the line and made dead the less the damage will be and the sooner the machine can be repaired and put back into service. To provide protection to alternating-current machines that will disconnect them from the line in case of internal trouble and not be affected by external overloads, a system of protection known as differentially connected relays has been developed. At first this was used only on larger generators, but its use has extended to transformers and motors. Generators as small as 500 kw. and motors of 50 hp. have been provided with differential-relay protection.

In contrast to overload relays, the current through which always bears a definite relation to the load current, there is normally no current passing through differentially connected relays. This statement can be better understood by referring to Fig. 1. The generator winding for a single phase is shown, with a current transformer connected in each lead and the transformers connected in series through an ammeter *A*. A relay coil *B* is connected across the terminals of each transformer. If it is assumed that the generator is supplying a load of 100 amperes and that the transformers have a ratio of 20 to 1, then a current of 5 amperes will flow through the secondaries of the two transformers in series and ammeter *A*. No current can flow through relay coil *B*, since the current from transformer *D* would tend to flow from *E* to *F*, while the current through transformer *C* would tend to flow from *F* to *E*. Since the two currents are equal and opposites, the resultant current is zero in relay *B*. Therefore, it can be seen that a differentially connected relay has no current flowing in its coil under normal conditions. Furthermore, it does not make any difference how large the load current may be in Fig. 1, there will be no current flowing through relay coil *B*. For example, if the load were to increase to 500 amperes, there would be 500 amperes flowing through the primary of transformers *C* and *D*, resulting in 25 amperes flowing in the secondary of the two transformers in series and through ammeter *A*, but no current would flow through relay coil *B*, for the reason already explained.

Ground Causes Operation of Relay

Assume that a ground occurs on one of the conductors, such as at *N*, and that a ground also develops in the generator winding at *X*, Fig. 2. In this case there are two paths for the current, one through all the generator winding and load as in Fig. 1, and another from the ground at *X* to *N* and back through the part of the generator winding between *G* and *X*. Suppose that after the ground occurs in the generator winding, the load current becomes 75 and the ground current 125 amperes. In such a case transformer *D* will have 75 amperes in its primary and transformer *C* the sum of the two currents, or 200 amperes. Since the transformer ratio is 20 to 1, *D* will have 3.75 amperes flowing in its secondary and *C* 10 amperes. The 3.75 amperes will circulate through the two transformers, and 6.25 will flow through relay coil *B* and transformer *C*, as indicated by the arrowheads. In other words, the difference between the currents in the secondaries flows through the relay coil, hence the term differential relay. Since the flow of alternating current is being considered, the arrows necessarily indicate instantaneous directions. Under ordinary conditions 6.25 amperes in the relay coil would be more than sufficient to trip the relay, causing the oil switch to open and disconnect the machine from the load.

Plunger-type instantaneous relays are usually utilized for differential-relay service, but induction-type relays are also employed for this duty. The windings of each type are usually designed to allow the relay to function

at any current between the limits of 1 and 3 amperes, hence when connected to standard 5-ampere secondaries, the minimum setting of the relays is 20 per cent of the primary current marked on the transformer name-plate. Thus when a failure occurs within the machine, it may be disconnected before the current reaches a value that would cause serious damage. Plunger-type relays provided with two windings are frequently employed for differential-relay service, the resultant magnetism in the common core being zero, except when more current flows in one winding than in the other.

Conditions Causing Relay Action

Fig. 3 represents a three-phase star-connected generator with three differential relays connected between the two groups of series transformers. For simplicity no tripping-circuit wiring or control wiring is shown. Regardless of the amount of current supplied by the generator and irrespective of any unbalanced condition

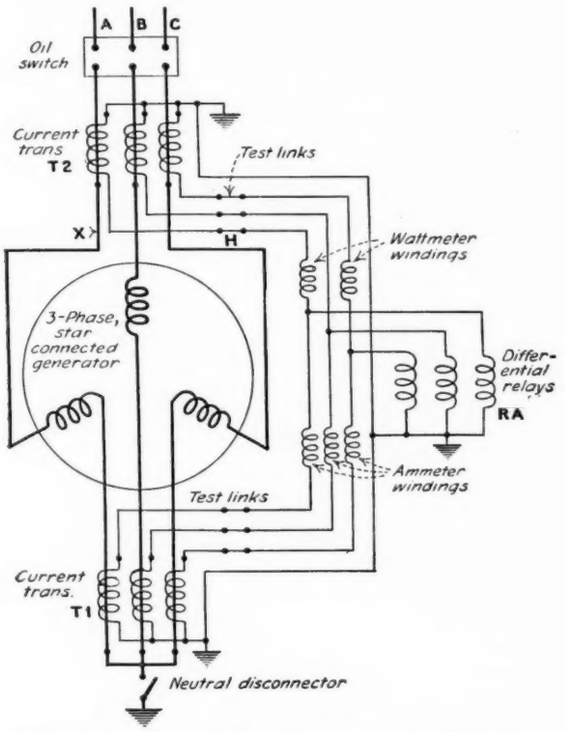


Fig. 3—Diagram of differentially connected relays on a three-phase star-connected generator

that does not result in a difference between the currents passing through the two current transformer primaries connected to any phase, the secondary currents will flow between the two groups of transformers. Under this condition no current will enter the differential relays, for it is assumed that equal impedances exist in the conductors between each relay and each secondary. If these impedances are not equal, a heavy overload may result in relay action if the setting is light; therefore, if the setting is made less than 10 per cent of rated current, care must be taken to connect the relays at the proper point in the secondary wiring and to insert additional impedance if necessary. With the secondary wiring properly balanced, each group of three transformers will supply one-half of the volt-amperes required by the secondary circuit.

Referring to Fig. 3 and assuming that the neutral disconnector is closed, the grounding of phase *A* at *X* will result in more current flowing through transformer *T*1 than through *T*2, and this difference will cause current to flow through relay *RA*. If relay *RA* is set to operate at 2 amperes, and the ratio of each current transformer is 100 to 1, and the primary currents in *T*1 and *T*2 are in phase with each other, when 200 amperes flows to ground at *X*, the relay will open.

Where the generator is connected to an ungrounded system, the occurrence of a ground in the conductors between the two groups of current transformers will ordinarily not result in differential-relay action, because sufficient current to close the relay contacts can rarely flow through such an isolated ground.

It is thus customary to ground the neutral point of a star-connected generator operating in parallel with others, thereby insuring differential-relay action if the generator winding becomes grounded. The grounding of the wiring of a generator connected to a grounded-neutral system will usually result in such rapid increase of current through the fault that the damaged generator will be promptly disconnected.

The occurrence of a short-circuit between phases in the generator will result in differential-relay action regardless of whether the neutral point is grounded or ungrounded, but a short-circuit confined to one phase only, such as between the turns of one armature coil, or the open-circuiting of any phase, will not be accompanied by differential-relay action, unless, as is usually the case, a phase-to-phase short-circuit or a ground results from these troubles. Trouble of any nature confined to the field winding will not cause relay action.

Field Switch Must Be Opened

Since the purpose of differential-relay protection is to disconnect a damaged generator promptly, so that it will not act as a short-circuit or ground on the system, and to de-energize it, thereby preventing extensive damage to the armature or core, closure of the differential-relay contacts must open the generator and field switches. If the field switch was not opened, a voltage would be generated in the windings that would cause current to flow into the fault as long as the machine continued to run.

Since the differential-relay contacts may open before the field switch has had time to open, a hand-reset device or an auxiliary switch is utilized to prevent the self-resetting of the relay until after the field switch has been opened. If an attempt is made to close the field and generator switches while the differential-relay contacts are closed, these switches will close but immediately open, since their respective trip coils are energized and prevent them from remaining in the closed position.

Unusual Causes of Relay Action

It should never be assumed that a fault has developed in the winding of a generator that has been cut out because of differential-relay action, for an open circuit in the secondary winding may cause the generator to be disconnected. For example, if the wire to the current transformer *T*2, Fig. 3, should become broken at *H*, the secondary current from transformer *T*1 would flow through relay *RA*. A short-circuit or ground in the control wiring may also cause the generator to be disconnected. When differential-relay action occurs the generator should be kept out of service until the cause has been ascertained, or until tests have indicated that the generator is in operative condition.

Alcona Dam on Au Sable River

By WILLIAM W. TEFFT*

Two-Unit 8,000-kw. plant operating under head of 41 ft. maximum ability at minimum cost typifies the design. Features of interest are the cubical design of plant with conduit spillway beneath the power house, thin reinforced-concrete corewall, construction methods enforced by the presence of quicksand, the casting of steel reinforced papier-mache conduit forms, etc.

THE Alcona dam of the Consumers Power Co , now under construction on the Au Sable River, in a few months will be ready for service. It is about 35 miles northwest from the City of Oscoda and will make the sixth water-power development of the company on the Au Sable River. The head at this point will be 41 ft. and the turbine water capacity will be 3,100 cu.ft.-sec. The installation is to consist of two 5,500-hp. single, vertical Wellman-Seaver-Morgan turbines driving at 90 r.p.m. three-phase 60-cycle 5,000-volt generators each rated to deliver 4,000 kw. at 92 per cent power factor. Six 78-in. conduits with butterfly valves will make up the spillway, and there will be an emergency spillway exterior to the plant.

The foundation is of sand underlain with ten to twelve feet of quicksand, below which the coarse sand again appears. It was impossible to pump out the quicksand without prohibitive cost, and so it was decided to confine it. Designed as a unit, the entire power house is carried on a monolithic slab 5 ft. 2 in. thick, heavily reinforced with the usual reinforcing steel in its upstream half, and with transverse steel girders 48 in. deep, spaced 2 ft. 6 in. apart on its downstream half. It was found after careful investigation that these girders were cheaper than reinforcing steel where the loading is so high and produced a more reliable design against settlement. The concrete slab is supported on round wooden piles driven on 2-ft. 6-in. centers each way to a depth of 70 ft., the top of each pile extending 6 in. up into the concrete slab.

*Vice-president and consulting hydraulic and civil engineer, Consumers Power Co., Jackson, Mich.

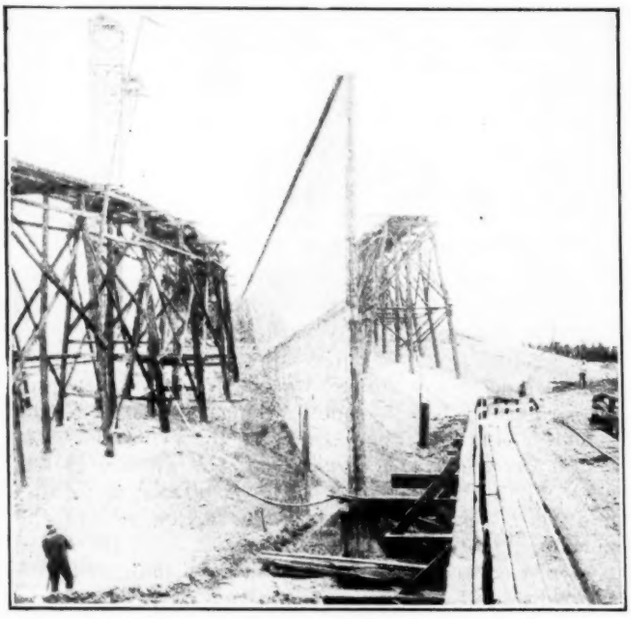


Fig. 2—Reinforced-concrete corewall

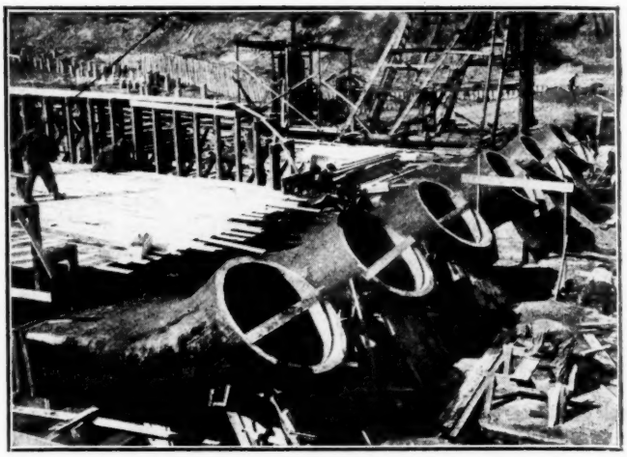


Fig. 1—Alcona power house under construction, showing spillway tubes

Obtaining a Foundation for Power House

Providing against the horizontal component of the forces acting on the power house was a problem of considerable magnitude. Ordinarily on clay or rock, or other good foundation material, this is amply provided for by the time stability against overturning has been established. At Alcona, however, where quicksand furnished a rather efficient though undesirable lubricant, this force is neutralized by means of the area of the downstream row of round piles and both the downstream and upstream wingwalls. The upstream walls possessed considerable value in this respect on account of the embankment, and so were tied into the power house with steel tension members.

Interlocking steel sheet piling was driven to surround the concrete slab, with the top of the piling made watertight at the slab. The piles were driven 55 ft. below the bottom of the concrete to form a watertight box closed at the top and on all sides, and open at the bottom. This box, which represents the plan size of the power house, is 115 wide by 170 ft. upstream and downstream. The steel sheet piling cutoff was carried both ways from the power house across the river valley underneath the corewall. The line of the steel sheet piling is shown by the heavy dotted line, Fig. 3.

Constructed above the steel sheet piling and connected to it with a watertight joint that allows for any settlement that may occur, the corewall extends up through the embankment to two feet above headwater and with an overhanging cornice at the top on the headwater side, like a sea wall, to prevent waves splashing over. This wall, which is relatively thin considering the great weight of the embankment on both sides of it, being 1 ft. 6 in. thick near the bottom and 12 in. thick for the top half, is reinforced, not with the idea of resisting any great lateral force, but to keep it from breaking in case of settlement or distortion. It forms an effective and cheap method of cutting off the passage

of water through the embankment as well as burrowing animals.

Perhaps the most interesting single factor of the Alcona development is the "Conduit Spillway" which has been patented[1] in this country and Canada. This method of design not only reduces the cost of the spillway to a negligible amount, but betters construction methods and power-house design to such an extent as materially to safety, and a cubical structure is produced at a minimum cost.

As will be apparent from the illustrations, the design of the spillway is simple and direct, consisting only of six 78-in. diameter conduits from headwater behind the racks through underneath the power house to the upstream end of the draft tubes, where they discharge along the draft-tube floor. The conduits are

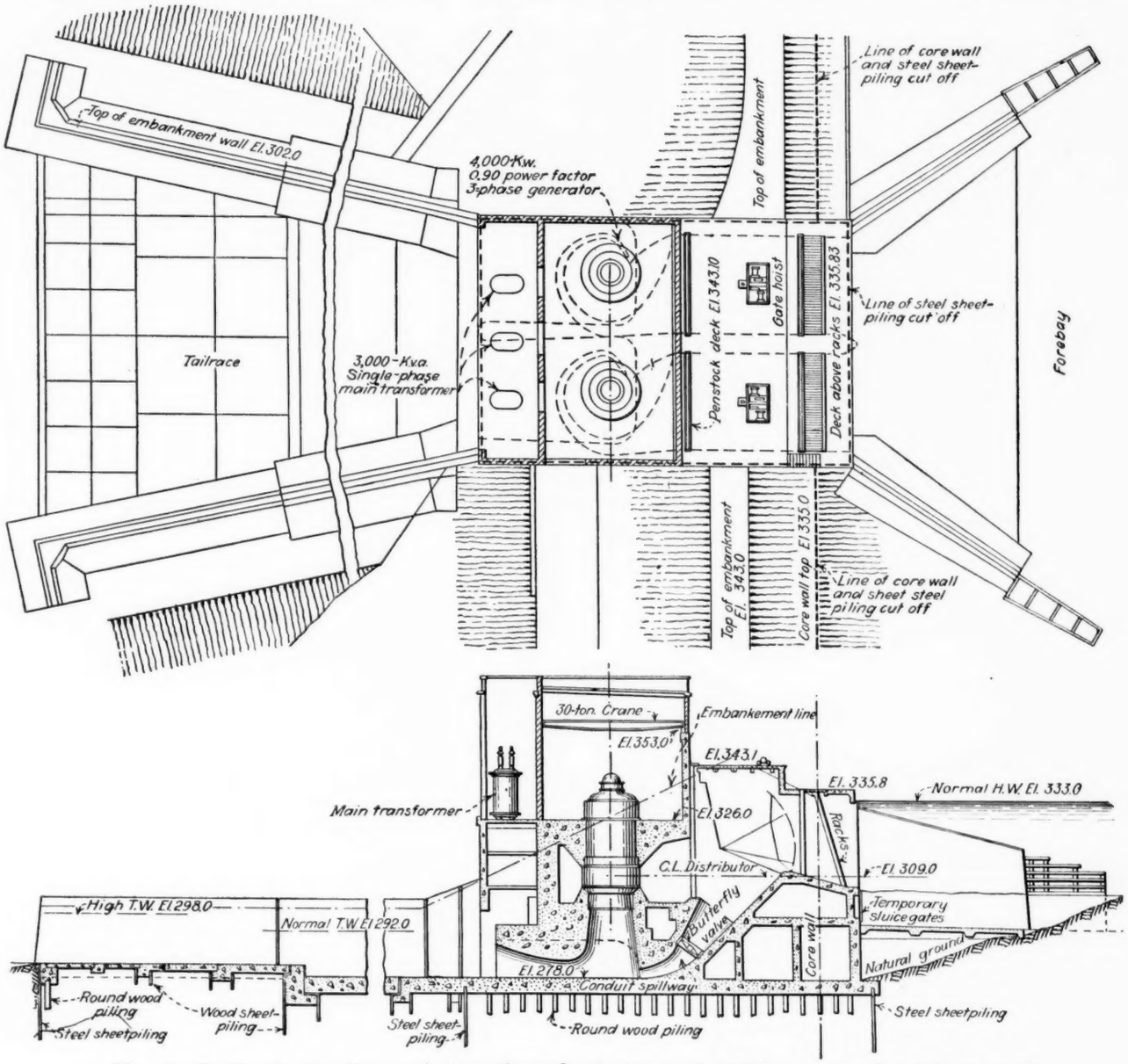


Fig. 3—Sectional elevation and plan through development which was constructed on sand

to make it possible to construct a safe structure on so poor a foundation.

Spillwater is discharged downstream quietly, thus eliminating danger of erosion of the soil foundation. The spillway is operated from the turbine room, making it unnecessary for the operator to leave his active machinery as is necessary with most other types of spillway, such as the tainter gate. A head increaser effect of definite amount is produced in high water when it is desired; freezing is eliminated, thus adding

[1]United States Patent No. 1,281,706 and Canadian Patent No. 188,695.

circular at the upstream end and change gradually to rectangular section at the discharge. The flow of water is controlled by six disk-arm butterfly valves operated directly by oil cylinders, the oil pressure for these cylinders being supplied by a small turbine-driven pump. All the valves may be opened in about 1¼ min. by opening one valve in the generator room, thus admitting head-water to the 6-in turbine. The piston rods extend through the cylinder and have an eye in the end so that in case of trouble the valve can be pulled open with a small chain falls from a hook in the ceiling of the tunnel.

For the conduits the forms themselves were novel, as only one was made of wood. Inside of this wooden form a steel reinforced papier-maché shell was cast, allowed to set and taken out. Then another shell was cast in the same way until all six were completed and set in the power house so that concrete could be cast around them, after which these papier-maché shells were removed. In this way the total cost of the forms for the six tubes was reduced to less than $1,000.

In the generator room there is just space for the two turbines and additional space for the dissembling of one of them. Headroom has been reduced to the low-

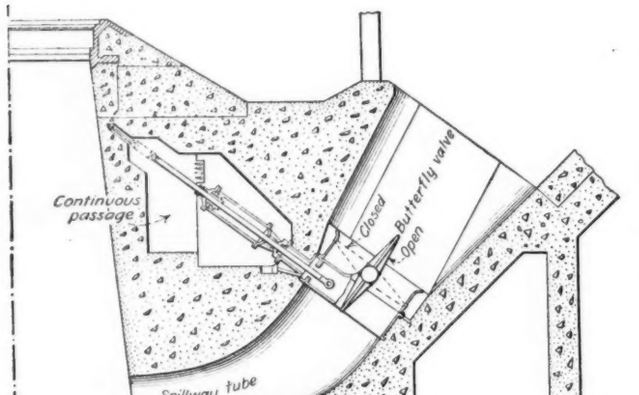


Fig. 4—Butterfly valve in spillway and operating mechanism

est possible by the use of twin cranes so arranged that the hooks lift the rotor by its spokes instead of the top of the shaft, thus raising the top of the shaft up between the two cranes. This single item reduces the height of the building some sixteen feet. Transformers are mounted on the downstream side of the power house, but outside the building and so arranged that they can be wheeled into the power house under the crane. By taking the thrust through the power house high retaining walls are eliminated. In fact, the entire structure, including the spillway, is designed compactly within the limits set by allowable water velocity (determining the width), stability and allowable soil pressures. There has been no increase of these limitations due to machinery or spillway. It would seem that under these conditions the design has been conceived to produce maximum ability at minimum cost for construction.

In a power-driven air compressor, in which all the driving power is applied to the shaft either through a wheel or by a motor mounted on the shaft, the machine should run "under." Rotation in this manner tends to keep the crosshead down on the lower guide, preventing the knock that would be produced by the lifting of the crosshead if the guides and shoes became worn. Considering the outward stroke, the crankpin draws the connecting rod outward and downward, and considering the inward stroke, the crankpin pushes the connecting rod inward and downward. Thus the crosshead is held down on the lower guide.

Steam Boilers

A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues

42. What is the approximate ratio of grate surface to heating surface in water-tube boilers?

Thirty-five to one is common.

43. In horizontal return-tubular boilers?

Forty to one.

44. What is priming?

The carrying out with the steam of a considerable quantity of water through steam outlets, the cause generally being the taking away of a quantity of steam considerably in excess of the quantity that should ordinarily be taken away in a given time.

45. What is foaming?

A violent agitation of the water causing foam to accumulate on the surface. The cause of the agitation generally is bad water or the presence of certain reagents, such as are contained in some boiler compounds.

46. What is water hammer?

The action of a quantity of water striking against an elbow or a closed valve is termed water hammer. If water is flowing through a pipe at considerable velocity and a stop valve in the line is suddenly shut off, the impact of the column of water against a valve or elbow causes a sound not unlike the striking of metal with a hammer. It is thought by some that the turning of live steam into a cold pipe or vessel results in rapid condensation, which, in turn, forms a vacuum into which a slug of water rushes until it encounters and strikes a bend, an elbow or a partly closed valve, thus producing a blow of great force. Any considerable quantity of air in the pipe will cushion the shock.

47. How would you stop foaming?

If burning coal, cover the fire with fresh coal, close all draft openings and reduce the amount of steam leaving the boiler. If burning oil, reduce the fire or shut it off completely.

48. How would you stop priming?

Keep the water at the lowest possible level consistent with safety and reduce the amount of steam leaving the boiler until it is equal to the amount evaporated at the rated horsepower of the boiler.

49. If a water-tube boiler containing 1,000 sq.ft. of heating surface normally evaporates 3,000 lb. of water per hour from a feed temperature of 200 deg. F. to a gage pressure of 150 lb., what is the proper size of spring-loaded safety valve?

A 2½-in. safety valve would relieve the boiler while evaporating 3,000 lb. of water per hour, but it is possible to evaporate six pounds of water per square foot of heating surface under certain conditions; so it is necessary to provide a valve that in this case will discharge 6,000 lb. of steam per hour. This would require a 3½-in. valve.

50. A stationary type of cross-drum water-tube boiler, working at or greater than rated capacity, shows a false water level in the gage glass. Why does the water in the glass remain at a different level from that in the drum?

When the main steam pipe connection is located on the head to which the water column is connected, the rapid outflow of steam reduces the pressure, so that it is less in the top water-column connection than in the bottom connection. The result is that the water in the glass and column rises to a higher level than the water in the drum.

Consumers' Economies*

By O. P. Hood†

Cheap fuel has been available since this continent was exploited. Clearing the fields gave cheap wood, and this was followed by abundant and cheap coal. The plentiful supply bred generous and wasteful habits in its use in domestic and industrial life. The standard of heating in houses is nowhere else so high, and power for industrial use has been in the past produced by the simplest equipment and methods. The attitude of mind of the public toward heat and its source is usually one of thoughtlessness, assuming that it should always be available in quantity at the bare cost of delivery.

The European thrifty use of heat, reducing service to a minimum and regarding the acquisition of a branch or a twig as an asset, is not a part of our habit. The result is that when fuel prices rise and quality declines, there is revealed a condition as to habit, practice and equipment which leaves ample room for economies. It is necessary to change our attitude of mind toward the sources of heat as a national and a personal asset. We must learn to value it properly, to regard it with respect and to realize the results of its lack. We can cut out needless service and reduce evidenced waste in nearly every field of use. John R. Freeman states that the price charged for hydraulic power in New England had remained substantially constant through fifty years, the improvement in efficiency of generating and distributing mechanism balancing the increased costs of labor and equipment. The same general effect obtains in power production.

How Large Industries Meet Advancing Price

The large industries meet the advancing price with improved equipment and with organized study of their heat problems. The steel industry improves its coking methods and uses its waste heat. The large mills using both heat and power enlarge their boiler units, introduce mechanical stokers or powdered fuel and put in bleeder turbines so that process steam may yield an increment of power before being used for a heating process. The producers of electric power greatly enlarge power stations and power units and bring to the furnaces of immense boiler units the refinements of scientific control. The firing of coal into a furnace of this kind is no longer a laborer's job, but has become an engineering problem of the first order, controlled by technically trained men.

Scientific methods are being applied to every problem in this field, which a few years ago was the most neglected spot in the industries. A few years ago an electric plant producing a kilowatt for each 25,000 B.t.u. supplied by the coal was considered in the front rank. The figure is now 16,000 or 17,000 B.t.u., and some of the newest developments promise 11,000 or 12,000 B.t.u. Formerly, if two-thirds of the heat of the coal was put into the steam available to the engines, it was considered good practice. Refined methods now put in over 85 per cent as a regular monthly practice. In this method of applying scientific knowledge to the problem of combustion and heat absorption in the various industries lies our most effective weapon to offset the inevitable rise in price of fuel.

The small industrial plant has responded to these new influences but little. Possessed of the equipment and the habits belonging to the age of too cheap coal, they meet the new situation with difficulty. There is a decided tendency to temporize, to dodge the fact that real brain work, care, attention and good management must be put on the hitherto dirty and unattractive furnace and boiler room in order to reduce costs effectively. The result is a crop of cast-iron cure-alls, fancy grates, devices to put on the firing door, elaborate leaks attached to the chimney, devices to put on the top of the chimney to do impossible stunts, perfectly good instruments sold to a man who will not learn how to use them, and a multitude of other makeshifts that usually end in a lost investment. Even salt to sprinkle on the tail of the fugitive B.t.u., in order to retard its flight, has been sold to sensible people here in Washington at a dollar a pound. Indorsements of these things are as readily obtained as were the indorsements of worthless patent medicines in an earlier day. One of the most practical tendencies is the substitution of central-station electric power for these small isolated plants, but where steam heat is needed this is not always advisable.

In the marine field the burning of oil, both under steam boilers and in internal-combustion engines, is increasing because of incidental economies in labor, time and space requirements.

Domestic Consumer's Influence on Conservation

The domestic consumer handles about a sixth of our fuel. His influence on conserving the general supply cannot be so great as that of the other main users, but his attitude of mind toward coal problems is of great importance and out of proportion to his tonnage interest. He buys the highest-priced coal, costing two or three times as much per ton as the industries pay, so that his financial interest is not represented by his tonnage interest. The art of burning coal he must pick up by himself. It is not taught with his arithmetic, nor does it go with his athletics. He sometimes makes a sorry mess of it, and at best it is a dirty, dusty and unwelcome job. When he tries to economize, he may choose to cut down on the service, to close a few rooms, lower the average temperature, or even forego a detached house and a yard for the kids, and move into an apartment. He may choose to cut down on the waste of heat, which means weather strips, double windows, insulation over top room ceilings, covering of pipes in the basement, pulling down window shades at night, and the introduction of supplementary heating devices for short-time use in fall and spring. He may decide to use cheaper coal.

Anthracite has been a nearly foolproof coal. While it can be misused and give low efficiency, it is surprising how highly efficient it is with the most ordinary care and attention. It is a mistake to consider the average efficiency low. From 60 to 80 per cent of the heat probably gets into the house if one half tries. It is for this reason that it is so hard to displace with substitutes, for each substitute requires the application of a little more thinking and a little more labor, two items we are loathe to give. In fact, this condition has produced an opposite effect to that of money economy. Instead of reducing the cost of this item of household economy, many are frankly facing an increased item in the budget for the winter's heat, and using oil or gas, but requiring a superior type of service that no other fuel supplies.

One of the most practical economies is to use the steam sizes of anthracite which must sell in competition with bituminous coal. Equally good service can be

*Paper presented before Washington Academy of Sciences.
†Mechanical engineer, United States Bureau of Mines.

had if means are provided to maintain a thin and uniform fire bed, or to supply artificial draft. The economy adopted by most people will ultimately be the use of bituminous coal. In this district it will be the so-called smokeless coals which we must learn to use. It will require more care and attention in firing and a frequent cleaning of furnace heating surfaces. When we are willing to do this in moderate amount, it will replace anthracite ton for ton. When we are ready to give really careful attention to the problem, we can get along with less tons, for the potential heat is 10 to 15 per cent more per ton. If we are not willing to do more than we do with anthracite at present, we may make up our minds to dislike the dirty stuff thoroughly and let it go at that, which is quite unreasonable.

High-Pressure Steam Line 3,600 Feet in Length

By E. E. Scott

We have become so accustomed to thinking of power-transmission lines in terms of steel towers and copper conductor that the idea of long-distance transmission of energy in any other form than electrical, appeals to us as novel. Power transmission in the form of high-pressure steam can hardly be looked upon as an efficient method, but under certain circumstances it may become the means of effecting great economies.

A line of such a character has just been completed and is now being successfully operated by the Pittsfield (Mass.) Electric Co. It is 3,610 ft. in length and is believed to be the longest high-pressure steam line in the world, operating as it does at 195 lb. It carries steam from the company's Silver Lake Plant to a down-town station, where it furnishes energy for operating a 750 kw. turbo-generator.

The station had become obsolete, and the company was confronted with a possible expenditure of $250,000 for the construction of a new one. However, after careful investigation it was found that for only $100,000 a steam conduit could be built and arrangements made with the Turners Falls Power Co. to secure extra power at the Silver Lake Plant. To supply this power, the power company has built a steel tower line 34 miles long from its central station at Turners Falls to Silver Lake. At present this power is coming in at 66,000 volts, but will be raised to 110,000 volts when plans for further expansion in Pittsfield and vicinity have matured.

Work was started on the steam line in October, 1922, and with the exception of the application of the pipe covering, all the construction work was carried through by the Pittsfield Electric Company's organization.

The pipe is covered with three inches of insulation consisting of two quarter-inch layers of fireproof felt over which is a layer of 85 per cent magnesia; over this is a protective jacket of heavy duck, while, to weatherproof the whole, a three-ply wrapping of rubberoid roofing paper is used.

For one-third of its length the pipe is laid in concrete ducts underground it being necessary to tunnel under two of the city's streets. During the remainder of the distance it is carried on concrete pillars above ground and rests on rollers set in the concrete, which facilitate movement between the expansion joints.

The pipe is of cast steel in special forty-foot lengths and is 8 in. in diameter. To take up the expansion of seven feet, expansion joints have been used at intervals of 210 ft., acetylene welding being employed at these points. The anchorages of this line are between each pair of expansion joints and are semi-rigid. A heavy machined plate is welded to the under side of the pipe at these points and rides in grooves machined in a casting which is in turn bolted to the concrete pillars. Owing to the great friction of this arrangement movement is very slight.

The greatest difficulty experienced during construction was to maintain the alignment of the pipe and compensate for its expansion, but a few weeks' operation has shown the latter features to have been worked out to a nicety.

If the line could have been made perfectly straight, no alignment difficulties would have been met, but it was necessary to make several sharp turns, one at the point at which the pipe enters the underground tunnel and another where it was necessary to conform to the lines of a bridge. At this point two nearly right-angle bends were necessary, and as buckling developed, it was necessary to cut out three inches of the pipe and weld a new joint. All other joints are also welded, including the expansion joints.

In the event of a break at any point in the line, the steam will automatically be shut off by means of a valve at the sending end, which closes when pressure drops.

One interesting feature in connection with the installation is the use of exhaust steam from the turbine for heating a row of business buildings in the center of the city.

Fig. 1—Rollers facilitate pipe movements

Fig. 2—Expansion joints are sheltered

Fig. 3—Where pipe enters a conduit

Why the Small Refrigerating Plant Predominates in California

Questions Arising in Considering Proper Prime Movers to Install—Kind of Cooling Water Used—Design of Condenser Found Desirable

BY H. L. LINCOLN

IN THE Sacramento and San Joaquin valleys there are many small towns separated by twenty miles or more of ranch land. To avoid costly transportation of ice it has been necessary to develop a small plant that will economically meet this condition. Several of these factories, having a daily capacity of thirty tons of ice each, have been put into operation during the year, and quite naturally some features of the design are noteworthy.

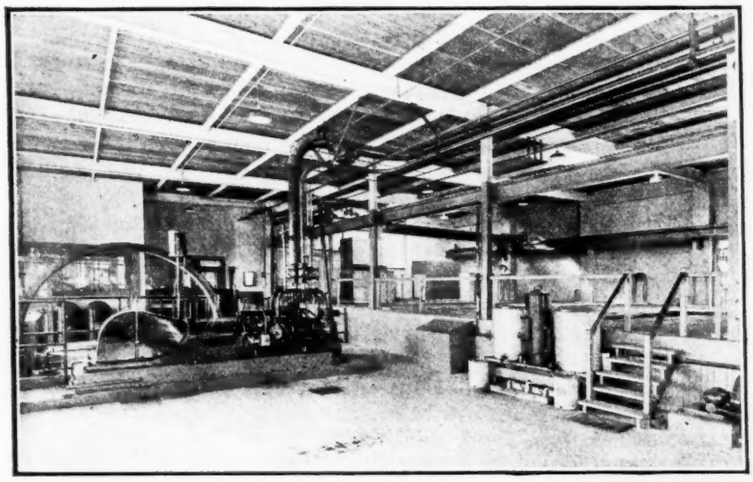


Fig. 1—Compressor room of small refrigerating plant

All those installed are raw-water plants, although in many cases the water might well be called unfit for ice making, even though it be in general use for drinking purposes. As there is no rainfall between the middle of April and late October, it is generally necessary to rely on wells, often driven 400 ft. in depth. The alternative is the purchase of the city water, and as may be imagined, the prices charged are high, 25 to 30 cents per thousand gallons being quite common. In many localities the raw water contains 15 or more grains of solids to the gallon, frequently running to 25 or 30 grains. When the solids may be removed by treatment, as in the case of the carbonates, the problem is merely that of selecting the best available softener. When the sodium salts predominate, good ice depends on the manner of agitating the water in the cans while freezing, as well as upon the attention given by the operator to removing the concentrated solids from the center of the block.

With hydro-electric power available in vast quantities the rates for electricity in California are sufficiently low, averaging 1¼ to 1½ cents per kilowatt-hour for a 100-hp. plant. There is, then, little necessity for considering any other form of motive power. Even at these rates it is quite possible that the cost of power alone could be reduced by means of an oil engine, and in a plant large enough to require one set of men to harvest the ice and another to operate the machinery, it certainly should be given careful consideration. However, in a locality requiring only a small plant engineers are not likely to be available, or if available and given an engine to run, they would find great difficulty in taking care of it properly and at the same time pulling ice. In any event, when the refrigerating side of the plant is properly proportioned, the total possible saving in power is of less importance than other production costs.

The compressor room and ice tank of a factory built in 1923 are shown in Figs. 1 and 2. The freezing tank is about 31 ft. wide by 30 ft. long and contains 18 rows of 24 three-hundred-pound ice cans. The ammonia expansion coils are arranged in 25 stands, 10 pipes high, a total in this tank of nearly 10,000 ft. To prevent the chance of leaks below the brine level, all fittings are eliminated, the coils being made up and tested in the shop and when in place, welded to the headers. The flooded system with an accumulator is used for three reasons: First, to increase the operating efficiency of the equipment; second, to permit the use of one expansion valve instead of several (hence requiring less attention); and third, to protect the compressor, as the chance of pumping over liquid is reduced.

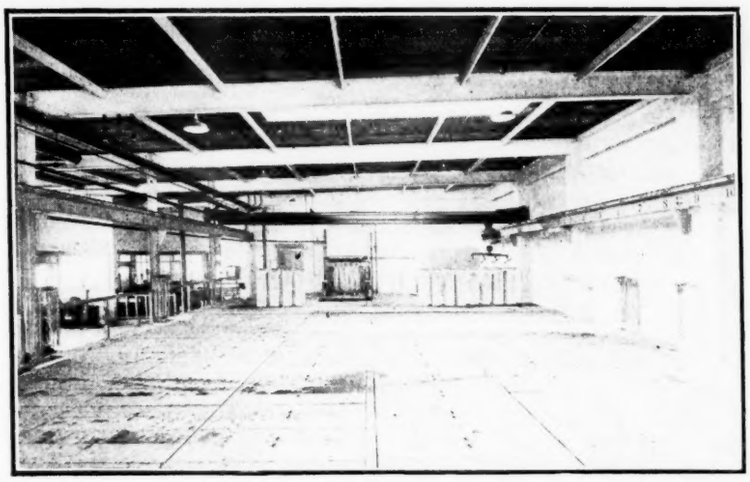


Fig. 2—Tank holds 432 ice cans

It is not enough to supply a liberal cooling surface and an accumulator to secure efficiency in a freezing

tank; there must be a positive and even circulation of brine. Unfortunately, most agitators merely agitate rather than circulate the brine. However, manufacturers are giving more attention to this point so that better results may be expected in the future. The vertical type, direct-connected to an electric motor, is a simple arrangement that is not likely to give trouble and, in addition, may be easily removed from the tank for repairs if necessary. At the usual motor speeds an excessive amount of power is required to move the brine, and frequently it is desirable to use the horizontal type, particularly in tanks where agitators are required at both ends.

Any one of the several types of compressors has some claim to superiority that would undoubtedly call for careful study in a larger plant. The most important characteristic of the compressor for a small factory is that it shall require little attention. Furthermore, conditions are very uniform, as most of the ammonia evaporates in the tank at a temperature of about 15 deg., only a small quantity being used in the forecooler and storeroom. As the condensing pressure may be kept below 150 lb. gage, no strain is placed on the machine and it is easy to get efficient pumping of gas. Whether a horizontal or a vertical compressor is selected, is of less importance than the size of the valves and connections and the speed at which it runs—about 100 r.p.m. for the former type or 160 for the latter. To relieve the operator from the duties of oiling, there should be a circulating lubricating system, as it will not only reduce the friction and maintenance, but will also give the man in charge confidence that the compressor will run without attention and thus increase his field of usefulness.

In recent years the bleeder type of condenser has been extensively adopted in California and, when sufficient surface is provided, gives excellent results. Formerly, the stands were made 18 pipes high, but in recent construction the 12-pipe condenser has been universally used; the total pipe surface required is the same, but the tendency to trap liquid ammonia is reduced.

While the design affects the temperature in that section where condensing actually takes place, directly influencing the pressure obtained, operating economy can be secured only by providing liberal pipe surface with a receiver large enough to prevent liquid ammonia backing up into the condenser when the system is charged sufficiently to insure sealing of the outlet at all times. For 30-ton plants 6 stands of 2-in. pipe, 12 high, give satisfactory service, in several plants the discharge pressure averaging 145 lb. gage and rarely exceeding 160. Comparing such a plant with one where the average pressure is 185 lb. and the maximum 205 to 210 lb., there is a saving of nearly 20 per cent in the power applied to the compressor. The advantage of ample condensing surface is evident.

Not only must there be adequate condenser surface, but there must also be a large quantity of condensing water at as low a temperature as possible. Where well water is available at a temperature of 65 deg., at least 25 gal. per stand of condenser is required. In many localities, to obtain well water it is only necessary to dig a pit some 20 ft. deep and put a centrifugal pump at the bottom. In other places a well is driven 300 or 400 ft. and either a well pump or an air lift employed. Often the amount of water available is unreliable and the supply likely to fail when most needed. Then it is necessary to resort to some means of cooling and recirculating the condensing water.

As the air temperature in the afternoon often exceeds 95 deg., the possibility of cooling water to below 70 deg. might appear remote. However, the air is so dry, or the relative humidity is so low, that this drop in temperature is obtained. The cooling tower usually consists of a number of decks of galvanized iron wire so designed that there is a large quantity of tray surface, and the tower is placed to get a maximum exposure to the prevailing winds.

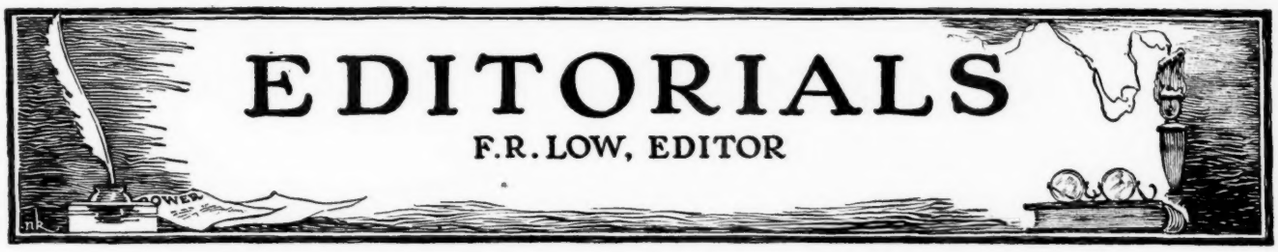
The only other machine in the compressor room is the unit supplying air to agitate the water in the cans while freezing. In a factory using the low-pressure system and requiring a large amount of air at about 3 lb. pressure, the positive blower is frequently replaced by one of the direct-connected centrifugal units. Under certain conditions a higher pressure, 25 to 30 lb. gage, is required, in which case a standard make of air compressor is installed.

These factories have a most creditable performance record as they are easily handled by three men working eight hours each. A fourth man relieves the operators three days a week and does maintenance work the rest of the time—a total of four men to produce 900 tons of ice each month. On the side of mechanical efficiency the record of the service meter presents definite data from which it appears ice is produced at an expenditure of 50 kw.-hr. per ton, a record that undoubtedly equals that of many plants of much larger size.

Stuck Pistons in Oil Engines

It is by no means uncommon to find that on an oil engine one or more pistons stick or freeze to the cylinder walls. This is traceable to three or four causes. In the first place some cast irons have a marked tendency to "grow," or increase in diameter. As a result the piston in time increases in diameter until close metallic contact is made with the cylinder liner. The engine loses power and finally stops. The freezing becomes so intense that the piston may be removed only with the greatest effort. This growth apparently is due to the iron having a low elastic limit under the high cylinder temperatures. The pressure then distorts the piston, which takes a permanent set since it has been stressed beyond its elastic limit. To correct this, the piston should be tapered from the top extending down to the first ring. The clearance at the edge of the top may well be as much as $\frac{1}{16}$ in. Some builders always taper the piston and have the straight portion extend only over the middle third of the piston length.

The second and more common cause of seizing, or freezing, of the piston, is lack of cooling water. This may occur both while the engine is in operation and after it is shut down. The former is evidenced by the loss of power and decrease in the engine speed and usually happens on a change from light to heavy load. The average operator understands that on full load the quantity of cooling water required is greater than in the lower loads. As the load comes on, the usual practice is to increase the flow of the cooling water. This chills the cylinder liner and causes it to contract before the hot piston experiences any effect from this additional cooling medium. This contraction lessens the working clearance; the piston becomes hotter and ultimately grips the liner walls.



EDITORIALS

F. R. LOW, EDITOR

Slipshod Lubricating Methods

A DISASTROUS explosion occurred in the Pekin, Illinois, plant of the Corn Products Company on January 3. Investigation has since revealed that a hot bearing had ignited a cloud of very fine dust particles. There is no doubt that many of the so-called spontaneous explosions in flour mills and other plants where material in a finely divided state floats in the air, have been due to similar causes.

Lubricating oil is not costly, in fact is one of the smallest items entering into the power costs of any factory. There is, then, no economic reason why bearings should be permitted to run in a hot condition. Indeed it may be stated with some assurance that seldom, if ever, does the question of cost have any influence.

As a general rule hot bearings may be traced to one of two causes. In too many factories the lineshafts are so placed that the hanger bearings are wellnigh inaccessible. It is expecting the improbable to depend upon the average oiler to crawl up over beams and rotating shafts to lubricate the journals. Too often the bearings must go the day with but a promise on the part of the workman "to oil it tomorrow."

In many industrial processes the likelihood of oil contaminating the product must be eliminated. If the shafting and bearings are poorly designed the dripping of oil can be prevented only by a reduction in the oil fed to the bearings, which are too often provided with but an oil well and a bit of waste.

In the design of any building the problem of lineshaft lubrication should be anticipated and provided for in the layout. If oil contamination is objectionable, there are many bearings on the market, of the roller, ball and other types, in which the amount of oil needed is almost insignificant and the dripping trouble avoided. No matter what bearing is used, the hangers should be so placed as to make the oiling possible.

Straightening Out the Heat-Transfer Tangle

NO ONE class of information is more generally needed in all branches of the engineering profession than that relating to heat transfer. In the field of power engineering alone it enters into the design of steam and internal-combustion engines, boilers, superheaters, economizers, closed heaters, surface condensers, evaporators, air preheaters, pipe covering, furnaces, generators, motors, refrigerating plants, etc. It has an immense number of applications in the heating and ventilating field in connection with the losses through building walls and the rating of steam and hot-water radiators. It enters into almost every phase of electrical design. It is of the greatest importance to the chemical industry. Similar conditions hold in almost every other branch of engineering.

Much work has been done on heat transfer by engineers in these various branches, as well as by physicists, but the theoretical and experimental difficulties are so great that many of the data are contradictory. As a result engineers have the greatest difficulty in selecting constants and methods of computation that can be relied upon.

Under the guidance of the Engineering Division of the National Research Council a group of prominent engineers familiar with the various angles of this great problem have taken the first step toward putting the house in order. In all probability the immediate program will include no new research work. It seems to be the general consensus of opinion that the great need just now is to dig up all that has been done along this line in various fields, to study it critically, digest it, and finally put the information into such a form that it may become a reliable guide for practical every-day work. Incidentally, such an inventory would be of great value in pointing out the logical line for future research. The great trouble with most of the heat-transfer research of the past has been that each investigator has plunged into his own little problem without sufficient knowledge of the work of other men. The result has been much duplication of effort and a great mass of assorted data, much of which is considered untrustworthy. The job laid out is a big one, but there seems to be enough backing to put it over.

A.S.H.V.E. Shows Fighting Blood

A FINE organization—resilient and full of energy! That is the impression every visitor must have carried away from the recent annual meeting of the American Society of Heating and Ventilating Engineers. If the rest of its members exhibit half the practical virtues of those who attended the convention, this society has a great future.

Right now it has 1,862 members, an increase of thirty-six per cent over last year. Last year it spent for research alone a total of thirty-three thousand dollars, nearly eighteen dollars per member. Its officers, council and committee members are, in the main, men of high professional standing in the field of heating and ventilation. Better yet, they are workers, as evidenced by the results produced. A good example is the code of minimum requirements for heating and ventilation, a preliminary draft of which has been completed. The fourteen subcommittees that prepared the several sections of this code have done a great piece of work in reducing to first principles an art in which hundreds of millions have been spent under rule-of-thumb guidance.

But is there no fly in the ointment? It almost seemed that there was when, at the Wednesday session, the motion was made that the Research Laboratory be closed for lack of funds. To the casual observer it

seemed that things were toppling when research—the very heart of the Society's activity—came under such direct fire. What a pity to see the structure torn down just as it was reaching its greatest usefulness!

Fortunately, this was only an optical illusion. The research committee and others close to the heart of the work used the method of King Solomon. They virtually said "Gentlemen, here is your laboratory. In all probability it doesn't suit you. Shoot it to pieces." The shooting started and never stopped for five hours. At the end there stood forth, not a demolished laboratory, but a solid structure with a few broken windows and cupolas and all obstacles to progress cleared away. It was the finest thing that ever happened.

The laboratory is to continue under a new and apparently more practical plan. The splendid work on fundamentals will continue with added emphasis on the immediate needs of the industry. The money will be there if the rest of the Society shows a devotion to research at all comparable to that exhibited at the meeting. In addition an endowment fund looms up as a possibility, although plans for this have not yet been formulated. The Research Laboratory will undoubtedly rise to its opportunities and clear its decks for even greater service to its industry.

The A.S.H.V.E. is to be congratulated on a membership capable of combining searching criticism with whole-hearted backing in time and money.

Saving Coal by Means of Higher Steam Pressures

IT IS not improbable that the pursuit of higher efficiency as characterized by developments in large stations may later be replaced to some extent by that of a broader economic utilization of fuel as frequently practiced in the small industrial plant. In view of the enormous amount of heat energy now being poured to waste into our rivers and lakes, through condenser discharge, many must feel convinced that there will surely come a change in conditions surrounding power generation in large stations.

Approximately speaking, three-quarters of the energy in a pound of coal is now wasted in the most efficient plants. About two-thirds of this waste is lost through condenser cooling water. The idea of utilizing this waste is frequently combated on the ground of commercial impossibility. Many feel, however, that we are rapidly approaching a condition where satisfactory solutions will be required. It is perhaps not generally realized that along with the increasing need of such economies, we are developing apparatus better fitted to cope with such situations.

The large station of the present time, operating at 250 to 300 pounds steam pressure, may furnish low-pressure steam or hot water as a means of selling waste heat. Under low temperature heads this energy requires a comparatively large volume of fluid for transmission. It must be utilized within short distances of the plant. It would therefore appear desirable to encourage industries requiring such heat to locate within this range.

Residential heating appears as a limited possibility. Furnishing steam above atmospheric pressure would produce a decrease in generating capacity, as approximately one-half of the load energy of a prime mover is abstracted from the steam at this pressure range to that of the usual exhaust. On the other hand, energy supplied from a straight high-pressure unit would be cheaper than that from one where condenser investment and operating charges are included. The net return, however, is dependent on the heating load curve and may not appear attractive.

Large amounts of expensive fuel are now consumed inefficiently and with much labor, in domestic heating. Combustion in a large station is vastly more efficient. Economically, domestic heating should receive attention.

The kilowatt-hour of 3,415 B.t.u. now retails at from three to ten cents. The same amount of heat supplied by means of gas sells at four to eight mills, practically one-tenth as much. For heating purposes the same amount as delivered by steam brings from four to ten mills, which is about equal to gas, at a rough approximation. A cubic foot of steam from 200 to 300 pounds would represent in heat content the range of that in a cubic foot of gas. On account of the pressure and temperature conditions, however, its cost of transmission in this state would be much more than that of gas.

The application of higher steam temperatures and pressures favors the exploitation of heat at lower heads in several ways. In the first place, the electrical energy practically available from a pound of steam at 500 to 1,200 pounds is appreciably more than that at 250 pounds. Condenser costs, are, relatively, less a factor. Extracted steam at low pressures represents less fuel burned per pound of steam. In the second place, it is possible to bleed or exhaust steam at higher temperatures and pressures, such as 250 pounds, 400 degrees or above.

A high-pressure unit is required for a prime mover at 1,200 pounds as arranged at the present time. Provision is more easily made for thermal storage, in smoothing out the demand on boilers.

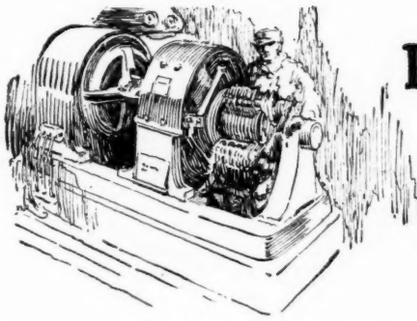
This offers greater opportunities for the commercial use of such heat. Requirements of steam at higher temperatures are likely to be more uniform than those of very low temperatures. Transmission at higher pressures requires less space and in this regard is better suited for longer distances.

This opens up a field for decentralization of power. Smaller prime movers may be distributed through a district, furnishing low-pressure steam at suitable points. Transmission-line loss is thus balanced against that of the steam line, and to some extent the lower efficiency of the smaller unit. The account of a steam line 3,600 feet long commercially operating at 195 pounds, appears in this issue.

Higher-temperature steam may make for a steadier domestic or manufacturing heating load. By supplying hot water and other requirements, to the exclusion of gas, an all year demand appears possible.

With Teapot Dome and the Mellon Plan for tax reduction occupying the attention of Congress, there appears to be little likelihood of coal legislation being enacted at this session. Perhaps the elements will continue to deal kindly with the consumer.

The American people are fond of slogans. Just at present "Superpower" is being greatly overworked, especially by those who have no conception of its physical scope and limitations.



Practical Ideas *from* Practical Men

Another Stack Loss

An ever-present but seldom-mentioned stack loss is that resulting from the water vapor carried by the air used for combustion. While this loss is small compared with the total losses, it comprises a large percentage of those losses labeled "unknown" on the heat balance sheet.

At atmospheric pressure, air at 62 deg. F. and 70 per cent humidity carries 10 oz. of moisture per 1,000 cu.ft. Assuming these atmospheric conditions and a boiler operation in which 18 lb., or 237 cu.ft., of air per pound of coal is being used, and a stack temperature of 550 deg., the extent of this loss would be figured as follows: Pounds water-vapor heated per pound of coal, $\frac{237 \times 10}{1{,}000 \times 16} = 0.148$; B.t.u. required to heat 0.148 lb. water vapor from 62 deg. to 550 deg., specific heat 0.5, $0.148 \times (550 - 62) \times 0.5 = 36.1$.

For a coal of 13,500 B.t.u. heat value, the percentage loss would $\frac{36.1}{13{,}500} = 0.27$.

L. V. CURRAN.

Copperhill, Tenn.

Some Ground Troubles on a Lighting Circuit

A system of ten lights connected in series is shown in the figure. The wiring was put under ground and was of the approved type, being insulated in a lead sheath and a steel covering for protection. The system had been in operation about a year, when a ground occurred on the circuit, but as this did not interfere with the plant's operation or the lights, it was not removed. One night the regulator that controlled the circuit began to act erratically, and finally the circuit opened up. It was found that with the switch in the power house open, lamps 1, 2, 3 and 4 were burning at about half candlepower, and the rest were out. Tracing out the circuit revealed that one wire *A* feeding the lamps had broken and came down across a street-railway power circuit, which was grounded on the negative side. This completed a circuit through lamps 1, 2, 3 and 4 on the railway power system.

After clearing up the trouble where the wire was broken, it was found that after the current was turned on the circuit from the power house lamps 1, 2, 3 and 4 only were burning the same as before the previously mentioned trouble was cleared. The current was turned off, and on testing out it was found that a ground existed at *B* and another at *C*, which accounted for the behavior of the lamps, as the current went into the ground at *B* and across to *C*, therefore cutting lamps 5 to 10 out of circuit. Upon digging the cable up at *B*, it was found that workmen in digging for a leak in a water main had driven the point of a pick onto the cable, pressing the steel sheath and the lead covering into the wire, thus causing the ground. This trouble was cleared and the circuit tested again with the current on and lamps 1 and 2 lighted. It was evident that another ground had developed somewhere between lamps Nos. 2 and 3, and upon investigation it was found where the wire had grounded on the base of the lamp standard. This was easily cleared, and upon putting the current on again, all the lamps came on all right. A ground

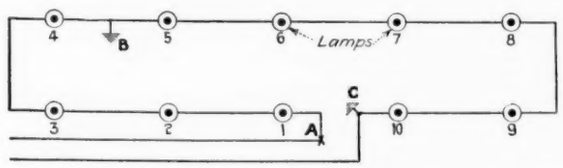


Diagram of lamp circuit showing location of faults

still existed at *C*, but owing to the earth's being frozen and as the lights were not affected by it, it was decided to let this go until more favorable working conditions prevailed. The repair was made during the following summer, and since then no further trouble has developed.

Fairfield, Me. LEON L. POLLARD.

How the Cylinder Joint Was Calked with Lead

Recently, while operating a large Corliss engine of a rather ancient type, the gasket between the cylinder and the frame blew out. We wedged and plastered the joint to no avail, and the superintendent concluded that the only way out was to shut down and dismantle the engine and put in a new lead gasket.

However, as this would require considerable time and the engine was needed every day, we decided to try wedging the joint once more. This time we molded a large cylinder of lead which we placed in the lathe, and by setting the tool high shaved off shreds of lead of great length. We then packed the bottom of the joint with fiber packing, driving it in with a tool made from an old hacksaw blade. We then placed in the joint strands of lead as large as could be conveniently forced into it, after which they were driven behind and between the bolts as firmly as possible. As soon as the spaces between the bolts were all filled flush, we twisted long strands and went entirely around the cylinder.

At first it seemed that our project was doomed to failure, as we were forced to start the engine before we had the job completed, and the packing blew out. At the second trial we completely filled the joint, and

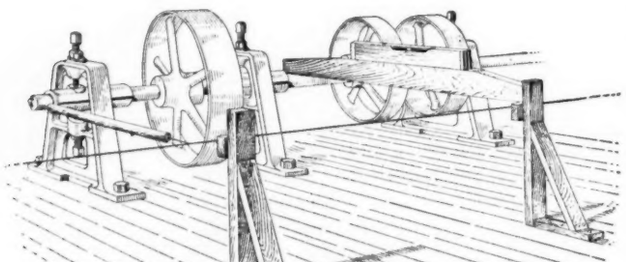
when it was finished we twisted a fine wire around the cylinder over the lead.

The job took a great quantity of the lead wool, and the turning off and calking in the lead required much patience, but it was successful in every way except for two slight leaks through bolt holes. LOE ADDY.

Newcomerstown, Ohio.

Aligning the Bearings on a Long Shaft

In a plant operating light and power machines a line-shaft 70 ft. long was driven by an engine at each end. Along the shaft, between several adjustable bearings, were clutch pulleys of different sizes for driving railway



Method of checking bearing alignment

generators, alternators and arc machines. It was found that by the wearing away of babbitt in the bearings the shaft had got out of alignment. The method we used of aligning this shaft is shown in the illustration.

A grass line was stretched between the walls of the building, parallel with the center of the shaft and adjusted by tram at each end. Targets were placed along the line, tacked to the floor, and blocks were tacked to the targets, level with the shaft at each end, which level was determined by the use of an accurate straight-edge and spirit level. The blocks were located on the targets by the use of the straight-edge and level, from one to the next, going over the work several times to make sure of the correctness of the job. Now, with the tram (a straight stick with a pin driven into each end) the shaft was tested at each bearing for horizontal alignment. The shaft was leveled by laying the straight-edge from the blocks to the top of the shaft and raising or lowering the bearing until it showed level. This method was found to work well and was used at other times. M. M. BROWN.

Utica, N. Y.

A First Aid Suggestion

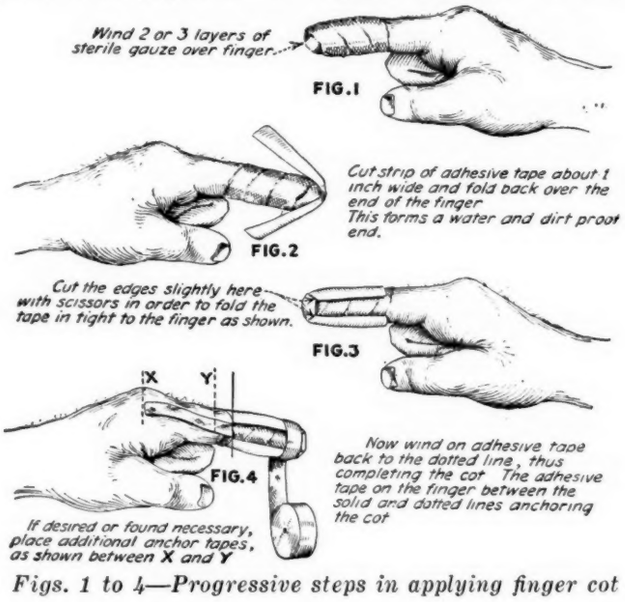
Having been engaged a few years ago on a large hydro-electric installation as assistant to the superintendent of construction and incidentally having as one of my duties the position of first-aid "doctor," I found that the majority of cases that I had to treat were bruised, cut, smashed or scratched fingers and generally of a minor nature but almost always hard to keep clean and hence hard to heal.

Workmen of all crafts are inclined to be a little careless with what they consider just scratches, and it often develops that the scratch is a more serious affair than at first supposed, and generally on account of the workman failing to keep the wound free from dirt and dust, thus inviting infection.

After trying various ways of bandaging up the injured fingers and failing to get a bandage that would keep the dirt out during the course of the day's work and that would stay in place and stand the wear and tear which included the work of laborers engaged in concrete work, etc., electricians, pipefitters, machinists, riggers, etc., I finally found the following method to give satisfactory results.

If the wound was a fresh cut or scratch, tincture of iodine was promptly applied, then the adhesive tape finger cot, as illustrated, was applied. Generally two such cots would be sufficient, as the cot will stay on for two or three days without wearing out, and as it is waterproof it can be washed clean in moderately warm water in the ordinary duty of washing the hands.

If the wound was an old one showing signs of infection, it was bathed with a 3 to 5 per cent solution of lysol and water, dried with a piece of sterile bandage or gauze and a small quantity of 1½ per cent carbolized vaseline applied, then finally covered with a few layers of sterile gauze, the number of layers depending upon the amount of apparent discharge from the wound. Care should be taken not to use too much of the vaseline. The finger cot was now applied and the workman required to report each evening after work for a change in the dressing and the cot. If the finger did not respond to this treatment, the workman was put on light work for a day or so and given instructions not to use the injured finger. By such procedure we put through the job and the care of a professional physician was required but once. We had


Wind 2 or 3 layers of sterile gauze over finger.
FIG.1
Cut strip of adhesive tape about 1 inch wide and fold back over the end of the finger. This forms a water and dirt proof end.
FIG.2
Cut the edges slightly here with scissors in order to fold the tape in tight to the finger as shown.
FIG.3
X
Y
FIG.4
Now wind on adhesive tape back to the dotted line, thus completing the cot. The adhesive tape on the finger between the solid and dotted lines anchoring the cot
If desired or found necessary, place additional anchor tapes, as shown between X and Y

Figs. 1 to 4—Progressive steps in applying finger cot

125 men to care for, 32 miles away from a regular physician, so I feel safe in recommending the use of the adhesive-tape finger cot as a reliable dirtproof and waterproof dressing for injured fingers.

Polson, Mont. W. DUANE TROW.

EDUCATION OF EXECUTIVES—On page 150, Jan. 22 issue, in the middle column, under the subheading "Education of Executives," the statements made under this title were accredited to F. F. Coffin instead of to F. F. Kauffman.

Comments from Readers

Presence of Mind in the Power Plant

The article by F. P. Terry in the Jan. 8 issue, entitled, "Presence of Mind in the Power Plant" brings to memory an incident that further emphasizes the necessity of a "presence of mind" test for power-plant employees.

In a large industrial plant the power generation and distribution was being changed over from 250 volts direct-current, to 2,300 volts three-phase alternating-current, and for a while both direct and alternating current were being used.

During the war the company was partly engaged in ammunition work, and a large shop was rigged up in less than sixty working days. It was equipped with some eight hundred 440-volt three-phase alternating-current motors, aggregating 4,000 kw. connected load with an average load factor of about 45 per cent. A portion of the shop was on a 24-hour basis, and as the load was unsufficient to justify the operation of the turbine, a 1,500-kw. rotary converter was being operated "inverted," receiving 250-volt direct-current from the reciprocating engine and delivering 2,300-volt alternating-current to a transformer station.

About 6:30 one evening the night watch engineer came running into the office of the electrical engineer (who happened to be late in the plant completing some work) and reported that the sprocket chain operating the field rheostat, located above the switchboard had broken and was hanging behind the switchboard, liable to cause a short across the busbars. The electrical engineer went to the power house, carefully fished out the broken sprocket chain and told the watch engineer to get a stepladder and operate the rheostat sprocket gear by hand. The operator inquired what the chances were of getting a shock. He was told that the chances were slim, unless the rheostat was grounded and the stepladder wet, and that a 2,300 volt operator has no business to worry about a 230-volt shock.

At this moment the master mechanic appeared and ordered the night master mechanic to repair the chain, against the advice of the electrical engineer. As the master mechanic had been working in the plant for some twenty-eight years and the electrical engineer only about 2½ months, the master mechanic's orders stood. The electrical engineer, after getting his work in shape, started for home and in passing through the power house, noticed the clumsiness with which the men were working on the sprocket chain. On his way to the trolley car he was thinking the matter over and decided to go back to the power house.

Scarcely had he stepped upon the turbine operating floor, when he noticed a "dip" in the lights and the rotary racing at a terrific speed with blue ring-fire around the commutator. Realizing what had happened, he made a "dive" for the circuit breaker. Whether he tripped the breaker or it tripped by itself just as he touched the button is immaterial. The converter was stopped.

When the excitement subsided, the electrical engineer started out to take inventory of the damage done. The night master mechanic was found stretched out on the engine operating floor, some four feet below the turbine floor. He was revived, but for several minutes couldn't open his eyes. He had been blinded, temporarily, by the flash. Whether he fell off the stairs or was thrown off he did not remember. He was not badly hurt.

As the electrical engineer surmised, a short-circuit on the rheostat opened the shunt field and the weak interpole and series fields were the only things that prevented the rotary from running away. The commutator was badly scorched, but there was no smell of burning insulation nor even signs of anything getting hot except the commutator. An investigation disclosed the fact that the overspeed device was inoperative, but the circuit breaker was in first-class condition.

The plant engineer, power superintendent, chief operating engineer and master mechanic (who had gone home after ordering the night man to repair the chain) were notified. Orders were given to start up another rotary and not to leave until a conference was held.

A "court-martial" was held at midnight. The frightened watch engineer attempted to put the blame on the electrical engineer, but the master mechanic assumed all the responsibility. The electrical engineer was exonerated and in the next pay envelope found a 25 per cent boost in his salary.

A ⅛-in. cut was taken on the commutator and the rotary started up again four days later. The sprocket-operated rheostats were later replaced by solenoid operated ones.

R. S. BROWNE.

New York City.

The Throttling Calorimeter

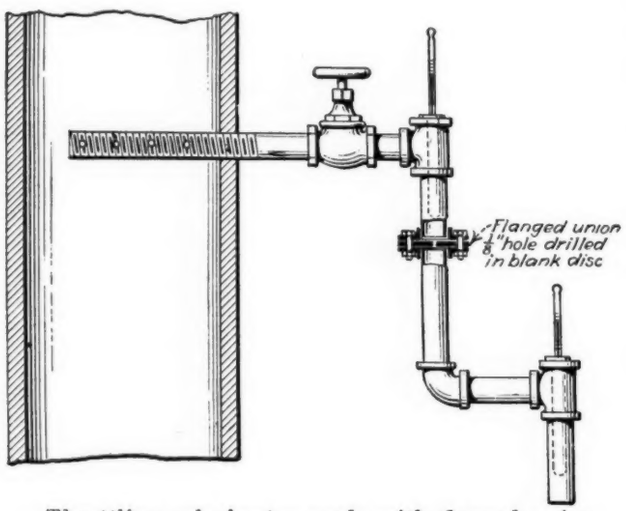
The article by T. M. Gunn in the Dec. 25, 1923, issue contained an excellent description of the throttling-calorimeter theory and its application to finding the moisture in steam.

Less praise can be given to the author's design of a simple form of calorimeter made of standard pipe fittings. In my opinion this design is open to criticism. The trouble lies in placing the thermometer well too close to the throttling valve. In this location the temperature of the steam is registered before its velocity energy has been turned into superheat. The trouble can be easily avoided by placing the thermometer well farther from the throttling valve, preferably after the stream has turned in an elbow in the pipe.

An example of the improved form of calorimeter is shown in the figure. This type was devised by George H. Barrus and, like the form described in the article referred to, is made of standard pipe fittings. The pressure drop occurs in the flange union, which is blanked off except for a small hole drilled in the center of the blanking disk. The upper thermometer is used merely to register steam temperature before throttling and is not essential to the use of the instrument.

Some years ago I had occasion to compare the defective type of calorimeter with the Barrus type, by placing both on a Y-branch fitting from the same collecting nipple in a steam pipe. Differences of twelve degrees in superheat were observed, and the thermometer close to the throttling valve always read too high.

I am aware that the criticized form of calorimeter has been described in engineering literature and apparently has been used to some extent. It seems proper to point out a defect in its design, especially since the defect can be avoided by a slight change in construction.



Throttling calorimeter made with flanged union

E. H. LOCKWOOD, Asst. Prof., Mech. Eng.,
New Haven, Conn. Yale University.

Phasing Out Alternating-Current Generators

Referring to the query of E. C. Curtis on page 857 of the Nov. 27, 1923, issue and the discussion on his question, the following may be of interest with reference to phasing out and making synchronizing connections to permit of paralleling the 300-kw. alternating generator, that is to be installed, with the 500-kw. machine:

Bearing in mind that it is unwise to make any assumptions when installing electrical equipment, it should be determined, by a careful examination and by insulation resistance measurements, that the generator is actually in good condition when received. If possible the resistance of the insulation between any generator terminal and the frame should be measured by a megger or high-resistance voltmeter. If dry and in good condition, the insulation resistance should be at least 1.8 megohms. If lower than this, the winding should be dried by short-circuiting the generator leads at such a point that current will flow through the ammeters. Operating the generator at reduced speed, the armature current should be held at approximately 75 amperes until the insulation resistance becomes normal. The generator temperature during the short-circuit run should not exceed 90 deg. C., as indicated on a thermometer attached by putty to the stator core. It is improbable, however, that drying will be required.

After the generator has been found to be in operative condition, and with the connections completed to the oil switch and to the voltmeter, which it is assumed can be connected to each phase by a plug, a voltage test should be made by slowly increasing the potential to 2,600 volts and holding it at this value for thirty minutes. During this period the generator and connected wiring should be carefully watched for any evidence of trouble, and the voltage across each phase should be read and found identical.

After completion of the voltage test a phase-rotation test is required to determine if the generator has been correctly connected to the oil switch. Referring to the figure, it will be noticed that the two center terminals of No. 2 switch have been connected together by a "jumper," and that the 2,200-volt windings of each of the two potential transformers have been connected between the remaining two pairs of switch terminals. Two 110-volt 16-candlepower lamps must be connected in series, as shown, to the 110-volt winding of each transformer. Since the voltage of No. 2 generator should be approximately equal to the bus voltage during this test, it will be necessary to mark the rheostat for this generator if the two potential transformers normally used with the voltmeter are connected across the switch during the test. Regarding the connections shown for phasing out No. 2 generator, only two potential transformers will be required, provided that, if 2,200-volt transformers are used, they are capable of withstanding double voltage during those instants that the generators are 180 deg. out of phase. If the potential transformers are in reasonably good condition, they will withstand this double voltage without damage. If four transformers are available, the connections given on page

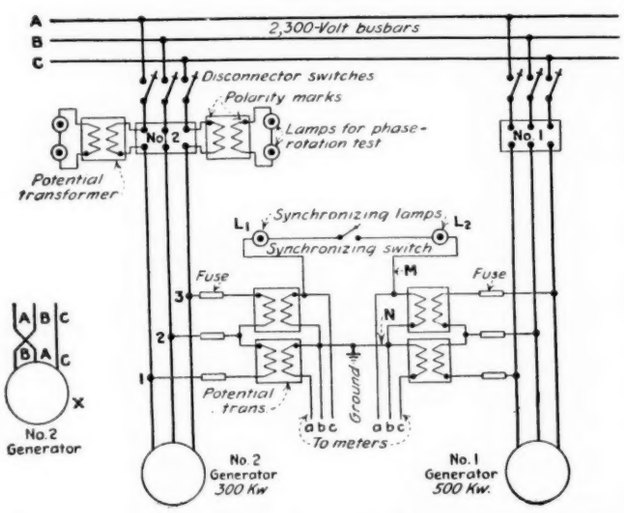


Diagram of connections for phasing out and synchronizing two alternating-current generators

65, Jan. 8 issue, by Mr. Dannenberg would be the best, for in this case double voltage is not applied to the transformer windings.

With No. 2 generator disconnectors closed, the field rheostat set at the mark corresponding to the bus voltage and the machine operating at normal speed, it will be found that the two groups of lamps vary in brilliancy, becoming alternately bright and dark. If the two pairs of lamps become bright and dark simultaneously, phase rotation is correct. If they glow at different degrees of brightness at any instant, their bright and dark periods not coinciding, phase rotation is not correct, and any two of the three wires connecting the generator with

the switch must be interchanged, as at *X* in the figure. After the leads have been interchanged, say at the generator terminals, the test for phase rotation should be repeated as a check. If correct, each pair of lamps will become bright and dark together, and the generator may be paralleled after the synchronizing connections have been completed.

As a further check for phase rotation, if it is permissible to de-energize the bus, No. 1 generator switch should be opened, and with No. 2 generator connected to the bus at normal voltage, a three-phase induction motor should be started. If the motor's direction of rotation is now the same as when operated by No. 1 generator, there can be no question as to the correctness of phase rotation.

Because generators in many small plants are paralleled successfully without the use of a synchroscope, synchronizing lamps alone being used, such an instrument need not be purchased. Assuming that the potential transformers required for the phase rotation test have been re-connected to No. 2 generator leads at points 1, 2 and 3 in the figure, with the synchronizing connections as shown, lamps L_1 and L_2 will be dark when the generators are in synchronism.

To prevent excessive voltage appearing on the secondary wiring, it is regular practice to ground this wiring at the connection between the two potential transformers, as indicated. With the wiring grounded at this point, the synchronizing lamps can be connected only to be dark at synchronism. If the secondary wiring is not grounded, the lamps can be connected to be bright at synchronism by interchanging two of the synchronizing leads, such as *M* and *N*. A small single-pole knife switch is to be used in place of a synchronizing receptacle and plug.

After the synchronizing connections have been made, the lamps should glow at about half of maximum brilliancy when the synchronizing switch is closed, while No. 1 generator is operated at normal voltage and No. 2 generator is at rest. Next operate No. 2 generator at synchronous speed with its voltage equal to that of No. 1 generator and note if the synchronizing lamps become alternately bright or dark. After it has been found by this test that the lamps glow properly, the synchronizing switch should be opened and the leads to No. 2 generator should be disconnected at the generator terminals and insulated to prevent a possible ground or short-circuit. Then by closing the synchronizing switch and No. 2 generator switch, the lamps, if connected across the same phases on each generator, should become bright or dark, depending upon which connection is used. With the generator leads disconnected and its switch closed, it is apparent that correct phase relations must exist to the terminals of No. 2 generator. If either zero or maximum voltage across the indicating lamps is not indicated by this test, a mistake has been made in the wiring, and after this has been remedied and the lamps become dark each time No. 2 generator switch is closed, assuming connections are as indicated in the figure, No. 2 generator switch should be opened. Be sure that potential is indicated across each phase by the voltmeter each time No. 2 generator switch is closed. After the synchronizing switch has been opened to de-energize the generator leads, they should be correctly reconnected.

The generators may now be synchronized by closing No. 2 generator switch while this machine is operating at synchronous speed at bus voltage. Waiting until the lamp beats become slow and uniform, count 1-2-3 from the time that the lamps become extinguished and quickly close No. 2 generator switch with a positive movement. The generators are now in parallel on the 2,300-volt bus, and if the foregoing directions have been followed, and except for possibly a brief period of hunting, they should operate satisfactorily in parallel. Bear in mind that the kilowatt output of each generator depends upon the power delivered by its prime mover, and that this output cannot be changed by adjusting the field rheostats, but by governor adjustment.

Caribou, Calif. RALPH BROWN.

Solid Injection Has Not Scored a Knock-Out

After reading the Year's Review in *Power*, Jan. 1, 1924, on "Development in the Oil Engine Industry," I felt as if I should go before the president of our company and propose to close up the plant; but after I had had a good night's rest I changed my mind, and even in the face of the discouraging article on the possibilities of building full Diesel engines of smaller sizes, I feel that we are justified in continuing our policy of bringing out small units ranging from 60 to 500 horsepower.

Before the war one of the leading Diesel concerns in Germany, the M. A. N., built as a regular product air-injection Diesels of 8, 10 and 12 hp. and so on. One may counter with the statement that wages in Germany are considerably lower than in this country, but this objection does not enter since this small-power Diesel had to compete with the hot-bulb engine.

Some manufacturers may believe that the solid injection, or semi-Diesel, engine is the most profitable engine to build and at the same time satisfactory to the owner, but I judge that this conclusion is arrived at by investigators going to plants newly put into operation or those that have been in operation only for a year or so. Unfortunately, these plants are not followed up and the trouble being encountered in actual operation does not become public.

The oil engine with solid injection requires a much finer adjustment, which is a problem in itself for the manufacturer and still more for the operating engineer, and it therefore takes a very good mechanic to keep an engine of this type in the shape in which it was brought out from the factory. There is no doubt that there are a great many good mechanics who love their engines and make a remarkable success with almost any kind of engine. Future investigations should be concentrated on the question of how the solid-injection, or semi-Diesel, engine stands up in comparison with the air-injection engine. I could quote cases where air-injection engines are kept in most deplorable condition and still they are running and giving service. This could never be duplicated with the solid-injection engine, and the designer ought to endeavor more and more to design his engine for such conditions. The very nature of solid injection will always remain a quite difficult mechanical problem, not only for the manufacturer but also for the operator.

I wish to state that with a highly developed engine such as ours and built on a basis of wholesale manufacture, we are sure that we can compete with an engine which *Power* feels has a future and at that bring out an engine which *Power* indirectly admitted in the review has higher qualities, but is only too costly to build.

Ashland, Mass. H. SCHRECK, Works Manager,
Lombard Governor Co.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Running Centrifugal with Discharge Valve Closed

Does a centrifugal pump require more power when run with the pump primed and the discharge valve closed than when delivering at full capacity? *F. C. E.*

When run with the discharge valve closed, the power required consists mainly of overcoming the frictional resistance offered to the impellers against movement of the water around in the case. When operated at full capacity, there is the additional work of raising the water and overcoming the pipe friction and pressure at the outlet, thereby making the power greater for regular operation than when merely running the pump with the discharge valve closed.

Strength of Dished Heads

What is the formula for safe working pressure for an unstayed spherical dished head with a manhole, when the pressure is on the concave side of the head? *H. G. N.*

When the pressure is on the concave side and there is a manhole in the dished head, the formula for thickness is

$$t = \frac{5.5 \times P \times L}{2 \times T\,S} + \tfrac{1}{4}$$

where

t = Thickness of steel plate, in.;

P = Maximum allowable working pressure, lb. per sq.in.;

TS = Tensile strength of material, lb. per sq.in. of cross-section;

L = Radius to which the head is dished, in., which is to be taken at not less than 80 per cent of the diameter of the shell or drum to which the head is attached.

By solving the formula for P, the maximum allowable working pressure is found to be $P = \dfrac{4\,TS \times t - TS}{11\,L}$

Purpose of Slack-Cable Device on Electric Elevators

What are the functions of the slack-cable devices on electric elevators, and where are they generally situated? *W. H.*

The function of a slack-cable device is to cause the elevator machine to stop should the hoisting or drum-counterweight cables become slack. On the modern machine one slack cable device is placed on top of the car and consists of an electric switch attached to one or more of the hoisting cables. Should the cable become slack, the device will open the switch, which, in turn, opens the circuit through the potential-switch magnet coil, thus allowing this switch to open. The other slack-cable device is located beneath the drum. It consists of a bar or strip placed in a horizontal position. Should either the car or drum-counterweight cables become slack, they will press down on the bar, which is connected with a lever and switch, the switch controlling the circuit through the potential-switch magnet coil.

Elevators with mechanical control have a slack-cable device consisting of a system of rods, levers and sheaves, inter-related and connecting with the controlling switch. The sheaves rest against either the hoisting cables or against both the hoisting and drum-counterweight cables. Should either become slack, the sheave, both by gravity and by the action of springs, travels circumferentially from its normal position and causes the controlling device to be brought to the stop position.

Required Kva. Capacities for Generator

We have an engine capable of developing 200 hp. at present, used for driving a lineshaft. It is intended to replace shafting transmission with electrical transmission, using the engine to drive a two-phase alternating-current generator with 75 per cent power factor. What size of generator would be required? *A. M. O.*

The required capacity would be $200 \times 746 \div 1{,}000 = 149.2$ kw., and with 75 per cent power factor the kva. capacity would be $149.2 \div 0.75 = 198.9$ kva., or practically 200 kva. Standard generators usually are designed for 80 per cent power factor, which would require $149.2 \div 0.80 = 186.5$ kva. capacity for the generator. As the losses in the generator have not been considered, and as the nearest commercial size is 200 kva., this should be used.

Advantages from Operating Both Forced and Induced Draft

Our boiler-feed water is heated in a closed heater from 40 deg. F. to the average temperature of 125 deg. F. by exhaust steam from an engine that drives the forced-draft fan, a stoker engine and boiler-feed pumps. We also have an induced-draft fan driven by a separate engine whose exhaust discharges through the heater. The forced draft is sufficient, but when the engines of both forced- and induced-draft fans are used, the feed-water temperature is raised from 40 to 165 deg. F. The boiler pressure is 150 lb. gage. How would the fraction of gain or loss of running both engines be estimated? *P. E. M.*

Since higher feed-water temperature is obtained, it is evident that more steam is used for operating the two fan engines than for operating only the forced draft.

However, there may be a saving due to the economy of two fan engines combined with the reduction of heat

required per pound of total feed water required. To arrive at the gain or loss, it is necessary to compare the quantity of heat required in each case.

One pound of steam at 150 lb. gage contains 1,195 B.t.u. above 32 deg. F., and when the feed-water temperature is 125 deg. F., the total heat received from the boiler per pound of feed water is (1,195 + 32) — 125 = 1,102 B.t.u.; and when the feed-water temperature is 165, or 40 deg. F. more, each pound of the feed water would receive 40 B.t.u. less, or 1,102 — 40 = 1,062 B.t.u., and for generation of steam each pound of feed water would require $\frac{40}{1,102}$, or about 3.6 per cent, less heat.

If F = steam used by the forced-draft fan engine when operated alone, pounds per hour,
C = the combined steam consumption of the fan engines when both are used, pounds per hour,
W = total weight of steam generated in the plant for all other purposes, pounds per hour,

then

(a) $(F + W)1,102$ = total heat that must be obtained from the boilers per hour when only the forced draft fan is used.

(b) $(C + W)1,062$ = the total heat to be obtained per hour when both fan engines are used.

If (a) is less than (b), the fraction of loss would be the difference divided by (a). But should (b) be less than (a), because the total quantity of steam required, although more, is generated by expenditure of less heat per pound, then the fraction of saving would be the difference divided by (a).

Overreaching of Corliss Governor

Why does our 22 x 48 in. Corliss engine fail to cut off properly? It cannot be due to overloading, as the trouble sometimes occurs when the engine carries less than the average load. F. M. S.

The trouble undoubtedly is due a wide range of governor movement for a small change of load. The load never is absolutely constant and the friction load of

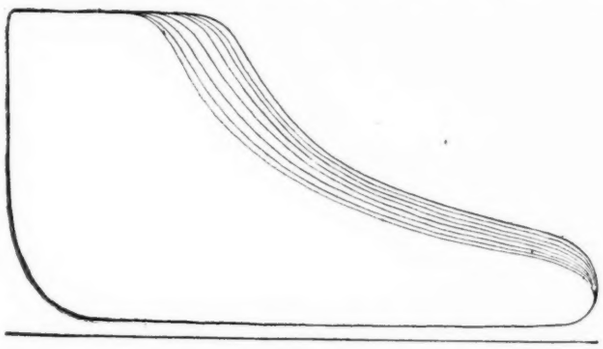


Fig. 1—Hunting action of oversensitive governor

the engine varies in every part of the stroke. With a flywheel of moderate weight the net effect is a constantly varying speed, which must be accompanied by variation of the governor position.

The governor responds, but momentum of the parts carries it so far past the proper position that release does not occur within the range of cut off. Then the acceleration of speed causes the governor to be carried past the proper position in the opposite direction. The hunting action may be due to oversensitiveness of the governor, or mechanical friction, or irregular slipping of the governor driving belt.

Indicator diagrams should be taken when the load is not quite sufficient to cause overreaching beyond the maximum cut off.

If there is a separate expansion line for every stroke when the pencil is held to the card during a number of

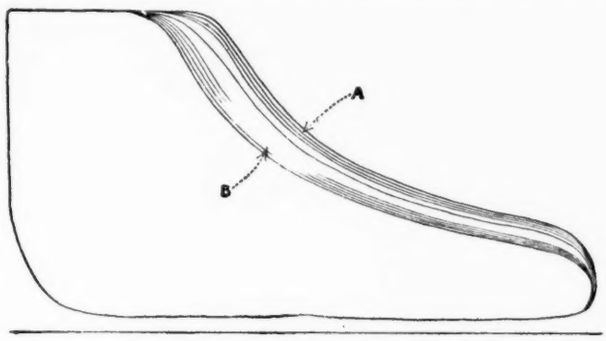


Fig. 2—Hunting action of sluggish governor

revolutions as shown in Fig. 1, that would signify oversensitiveness of the governor, which should be provided with a dashpot to limit the rate at which a change of position can take place. The fluid friction should be regulated to prevent rapid movement but to offer practically no resistance to very slow motion.

If indicator diagrams of a number of consecutive strokes appear to be more nearly superimposed in groups like A and B in Fig. 2, the trouble of overreaching may be attributed to sticking of the governor and the remedy would be to clean and overhaul the governor and provide it with good lubrication.

Noise from Slapping of Piston Rings

We have a pair of hoisting engines 24x42 in., using steam at 150 lb. gage, superheated 100 deg. F. Each piston has a bull ring 7 in. wide and snap rings which are set out by adjustable half-moon springs. The engines run very quietly under full steam and load, but while coasting at fairly high speed there is a slap or pound that seems to come from the pistons. What causes the noise? M. A. J.

If the noise proceeds from the pistons, it undoubtedly is caused by side play of the rings and sudden change of cylinder pressure from one side of the pistons to the other. It would be difficult to predict just what variations of pressure occur during coasting without knowing the valve setting and assuming that the valves are absolutely tight, which is hardly to be expected. Indicator diagrams taken during coasting would reveal the distribution of cylinder pressure during the stroke and demonstrate whether there is a sudden change of pressure from one side to the other of the pistons. If the trouble seems to be due to side play of the piston rings, the actual construction will suggest how a closer fit can be obtained with a view of stopping the noise.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

What Goes Up the Stack?

WHAT goes up the stack? The natural answer is "smoke," but that is wrong, if by smoke is meant what is visible. The visible smoke consists of fine particles of carbon which ordinarily represent less than one per cent of the total weight of material passing up the chimney. What passes up might more properly be described as "coal and air." The form and arrangement of some of the molecules has been changed, but except for the ash and the small amount of carbon that falls through the grate with the ash, all the coal, all the air and nothing else, goes up the chimney.

Sixteen Tons of Air

Suppose that the air supplied to the furnace amounts to 16 lb. for every pound of coal fired. Then, for every ton of coal burned, 16 tons of air enter the furnace and practically 17 tons of gases pass up the stack. Strictly speaking, the amount is less than 17 tons, by the weight of ash and refuse that falls through the grate. This might average around 0.15 ton, leaving 16.85 tons of flue gas.

Since nothing but coal and air goes up the stack, the stack gases contain only those elements that are present in the coal and air. Moreover, the weights of these elements are unchanged. The air contains two elements, oxygen and nitrogen.[1] These are also present in the coal, along with a large amount of carbon, a smaller amount of hydrogen and a trace of sulphur. Other elements are present in the ash, but these need not be considered if it is assumed that none of the ash is carried up the stack. Therefore, the preceding list gives all the elements of any importance that are found in flue gas.

The amount of these various elements in the flue gas from a ton of coal depends on the composition of the coal and on the weight of air supplied per ton of coal. For the purpose of illustration we may assume a typical bituminous coal of the following analysis:

Element	Per Cent	Pounds in One Ton
Ash	9.80	196
Sulphur	3.77	75
Hydrogen	4.62	92
Nitrogen	1.14	23
Carbon	76.42	1,529
Oxygen	4.25	85
Total	100.00	2,000

If no good fuel is lost through the grate, all the preceding except the ash passes up the stack. Along with these must go the elements in the 16 tons of air supplied. By weight air is 23 per cent oxygen and 77 per cent nitrogen, so the total weight of these two substances in the air supplied is as follows:

Oxygen	7,460 lb.
Nitrogen	24,540 lb.
Total	32,000 lb. = 16 tons

Adding in the amounts of nitrogen and oxygen in the coal, we have

lb.

Total oxygen = 7,460 + 85 = 7,545
Total nitrogen = 24,540 + 23 = 24,563

It is now possible to write down the total weights of the various elements in the flue gas from one ton of coal, assuming that nothing but pure ash falls through the grate. The list follows:

Element	Weight, Lb.	Approximate Weight, Round Numbers
Nitrogen	24,563	12.3 tons
Oxygen	7,545	4 tons
Carbon	1,529	1,500 lb.
Hydrogen	92	90 lb.
Sulphur	75	75 lb.
Total	33,804	

It will be noted that the total falls short of 17 tons by 196 lb., which is the weight of the ash that falls through the grate.

Twelve Tons of Nitrogen

The table shows that when a ton of this coal is burned with 16 tons of air (a fairly reasonable ratio), about 12 tons of nitrogen pass up the stack along with about 4 tons of oxygen, about 1,500 lb. of carbon, about 90 lb. of hydrogen and 75 lb. of sulphur.

It should be remembered that the weights given in this table are for the actual elements. Only part of the 3.8 tons of oxygen, for example, is in the form of free oxygen or oxygen gas. Some of it is combined with hydrogen in the form of water vapor, some with carbon as carbon dioxide (CO_2) and possibly a little carbon monoxide (CO). Still another portion of the oxygen is combined with sulphur in the form of sulphur dioxide (SO_2). But the sum of all the oxygen in these various compounds and that remaining as free oxygen, or oxygen gas, must total 3.8 tons.

The nitrogen will all appear as free nitrogen gas since this element does not form compounds under ordinary furnace conditions. It is just carried along as a dead substance that serves no purpose except to dilute the other gases. While nitrogen does not enter directly into combustion its presence has a decided effect on practical operation. The burning of a ton of coal releases a certain amount of heat whose first effect is to heat all the gases present to a high temperature. The smaller the amount of gas present the higher the temperature.

The presence of a large amount of nitrogen thus serves to keep the furnace temperature down. In cooling the furnace it protects the brickwork but reduces the efficiency, since a larger amount of hot gases passes up the stack. If the nitrogen could be completely eliminated by supplying oxygen instead of air, the furnace would be destroyed almost instantly by the intense heat. On the other hand too much nitrogen is ordinarily present due to the fact that much more air is supplied than is needed to burn the coal.

Of course heat is likewise carried away in the other gases, but attention has been concentrated on the nitrogen because in every case it weighs more than all the other constituents combined.

The Actual Constituents

It is not difficult to figure the weights of the various compounds in the flue gas if it is remembered that the elements combine as follows:

One pound of	Combined with	To form
Hydrogen	8 lb. oxygen	9 lb. moisture
Carbon	2.67 lb. oxygen	3.67 lb. carbon dioxide
Sulphur	1 lb. oxygen	2 lb. sulphur dioxid

Thus the 92 lb. of hydrogen will be combined with $8 \times 92 = 736$ lb. oxygen to form 828 lb. moisture. The 1,529 lb of carbon will be combined with $1,529 \times 2.67 = 4,082$ lb. oxygen to form 5,611 lb. carbon dioxide. The 75 lb. of sulphur will be combined with 75 lb. of oxygen to form 150 lb. of sulphur dioxide. Leaving out the possibility of carbon burning to carbon monoxide, these three are the only ways in which oxygen can be tied up with other substances in the flue gas. The free oxygen will be the amount left over. Adding the amounts of oxygen combined in these various ways, we have:

	Lb.
Oxygen in moisture	736
Oxygen in carbon dioxide	4,082
Oxygen in sulphur dioxide	75
Total combined oxygen	4,893

Subtracting this from the total of 7,545 lb. of oxygen, gives 2,652 lb. of free oxygen gas. We then have the following weights of the actual compounds going up the stack when one ton of this coal is burned with 16 tons of air:

Substance	Weight, lb
Nitrogen (gas)	24,563
Carbon dioxide	5,611
Oxygen (gas)	2,652
Moisture	828
Sulphur dioxide	150
Total	33,804

The weights here come to the same total as the weights of the elements, which gives a good check on the computations.

[1] The moisture in the air is not considered.

Research a Storm Center at Heating Engineers' Convention

NOTABLE advances in the arts of heating and ventilation were made public at the annual meeting of the American Society of Heating and Ventilating Engineers, whose sessions were held in the Hotel Pennsylvania, New York City, Jan. 22-25. The technical papers presented covered a variety of subjects, those of particular interest to steam and power engineers dealing with the use of heat from central heating plants, the place of electricity in the heating field, the development of a new heat-flow meter, critical velocity of steam and condensate mixtures in pipes with various slopes and the application of the Kutter formula to flow in small pipes. Important as were these papers, particularly that describing the experiments with the new heat-flow meter, the report on the proposed code for heating and ventilation was of even greater interest. Most important of all was the extraordinary discussion and momentous action precipitated by a motion that the Research Laboratory in Pittsburgh, started five years ago, be closed.

Bringing to an immediate head certain difficult problems of finance, this motion provoked a discussion that continued for nearly five hours. The final result insures the continuation of the laboratory on an even greater scale with the backing of members prepared to secure its financial support by collecting a fund for immediate needs and investigating the feasibility of raising a huge endowment fund, for which the goal of one million dollars has been tentatively set. More will be said of this in outlining the Wednesday, Thursday, and Friday sessions.

New Officers Elected

After the opening business session Tuesday evening, Jan. 22, the election of the following officers for the ensuing year was announced: President, Homer Addams; first vice-president, S. E. Dibble; second vice-president, William H. Driscoll; treasurer, Perry West. Members of the Council: F. Paul Anderson, Willis H. Carrier, Joseph A. Cutler, H. P. Gant, Walter E. Gillham, L. A. Harding, Alfred S. Kellogg, Thornton Lewis.

In the afternoon session, Lee P. Hynes, chief engineer, Consolidated Car Heat Co., Albany, N. Y., presented a paper on the place of electricity in the general heating field. This paper, while containing no radically new material, gave a useful compilation of the special applications, advantages and limitations of electric heating. Among the advantages mentioned were convenience, flexibility, possibility of using in the form of direct radiant heat, combined radiant and convected heat, etc., 100 per cent utilization efficiency, less waste through overheating and no vitiation of the air.

Mr. Hynes admitted that for any wide application the cost of current must be less than one cent per kilowatt-hour. Even at this price electric heat was equivalent to coal costing $37.73 per ton used with 50 per cent efficiency. Allowance for operating factors somewhat improved the showing of electric heat. Where hydro-electric power would otherwise be wasted, he showed that it might advantageously be used for heat in electric boilers.

During the Wednesday morning session a paper on "Economical Utilization of Heat from Central Stations" was presented by N. W. Calvert and J. E. Seiter. An abstract of this paper, which showed how large savings could be made, will appear in an early issue.

Dean Anderson Lauds Research

The Research Session on Wednesday afternoon was devoted to three papers outlining the results of research in the Society's laboratory in Pittsburgh. This laboratory is housed in the buildings of the Bureau of Mines and receives its working space, heat and light, as well as considerable general co-operation, from that source. The session was started with an inspiring address by the Director, F. Paul Anderson, Dean of Engineering at the University of Kentucky. In spite of their splendid minds, said Dean Anderson, the Chinese made no progress because they did not back their reasoning with a search for the facts of nature. Western progress was due to the work of such men as Bacon, Watt, Fulton, Morse, Wright and Marconi, who did pioneer work in unknown fields. The wonderful progress of the last hundred years has resulted not merely in material comforts, but in general advantage in every phase of life, social, artistic and moral.

He pointed to some of the great industries that have actively engaged in research as examples of what can be accomplished where industry builds on a solid foundation of scientific fact.

One of the great fields of research, said Dean Anderson, is in the building industry, the three great divisions being materials, fabrication, and heating and ventilation. The race is changing rapidly from outdoor life to indoor, so that the heating and ventilating engineer would have an increasing responsibility for the general welfare of the community. He spoke of the papers to be presented as important contributions to scientific progress.

Heat Meter Has Great Possibilities

Dean Anderson's address was followed by what was generally conceded to be the outstanding technical paper of the convention. This paper, "Measuring Heat Transmission in Building Structures, and a Heat Transmission Meter," was presented by P. Nicholls, and described the development of a meter by which the flow of heat can be measured directly just as orifices and other similar devices measure the flow of fluids. The principle of this meter is old, but its practical development apparently marks a turning point in the science of heat transmission.

The meter, of which several models have been made and tested, consists of a thin built-up plate two feet square. The central layer is fairly thin (in one case $\frac{1}{16}$ in.) and made of a non-metallic material of sufficient heat resistance to cause an appreciable difference of temperature betwen the two faces for a small rate of heat flow. On the two sides of this sheet are embedded a large number of thermocouple junctions so connected that the voltage difference between two main terminals is proportional to the average temperature drop through the sheet.

This voltage is measured by a potentiometer. The instrument is calibrated by placing the meter in a special apparatus where a measured amount of heat can be passed through it with a given surface temperature. By means of the calibration curve thus prepared, the potentiometer readings can be translated directly into B.t.u. per square foot per hour *flowing through the meter.*

Can Be Placed on Any Wall

Hence, if placed on the inner wall of a building, this meter reads directly the heat flowing through it, which is also the heat flowing into the wall. If conditions are stable, the same amount of heat is passing through all sections of the wall. Under such conditions the meter shows the heat passing *through* the wall, and the meter's action is comparable to an ammeter whose coil is made part of an electric circuit to measure the flow. As in the case of the ammeter, the resistance of the material interposed reduces the flow, but the effect is not serious if this resistance is small compared to the total. The meter board is made thin enough so that its resistance is small compared with that of an ordinary wall. For other uses the thickness and material of the meter would be suitably varied.

The paper went into considerable detail as to the theory, method of construction and calibration, and the results obtained. The author felt safe in guaranteeing an error of less than one per cent under laboratory conditions and of less than two per cent when applied to an average wall with unequal contact.

Remarkable Sensitiveness

A meter on exhibition at the convention was so sensitive that, after the potentiometer was balanced, the heat of a hand held two or three inches from the plate would immediately throw the galvanometer beam off the scale.

Mr. Nicholls suggested that his meter, suitably constructed, was well fitted to measure the heat losses through furnace walls. In the discussion many members expressed their appreciation of the importance of this apparatus and of the painstaking labor involved in its development. The question was raised as to the possibility of error due to variations of temperature on the surface. Mr. Nicholls said this did not appreciably affect the average

value of the heat flow on account of the large number of thermocouples used. It was suggested that such a meter would be useful in checking up guarantees of heat loss through pipe covering. A representative from the Pennsylvania State College described the work done there on heat meters after abandoning other methods of measuring heat losses through insulating materials.

Steam and Condensate Mixtures

Next came the paper on "Critical Velocity of Steam and Condensate Mixtures in Horizontal, Vertical and Inclined Pipes," by F. C. Houghten, Louis Ebin and R. L. Lincoln. Tests were made to determine the maximum possible steam velocity in pipes serving the combined purpose of carrying steam to a radiator and bringing back the condensate. The limiting factor is the sweeping of the condensate back up the pipe by the steam. The experiments showed that the maximum velocity was practically independent of the length and was greatest for a pitch between 45 and 55 deg. for all pipe sizes. The maximum values in feet per second were 45 for ¾-in. pipe, 47 for 1-in. pipe, and 54 for 1¼-in. pipe. With a vertical connection these values fell to 25, 29 and 37 ft. per sec. respectively. The experiments also showed that reaming the pipe entrance had a great effect on the maximum velocity.

Various practical considerations were brought out in the discussion. One was that it is sometimes cheaper to use a larger pipe than to carry the inspection expense needed to insure burr removal.

At this point the technical papers were stopped to bring up a matter of greatest importance to the society. Thornton Lewis, acting for the Research Committee, gave the following financial data on the research laboratory: 1923—Actual expenditures, $33,028.88; budget provision, $34,050. 1924 Income —Cash on hand, $7,737.42; (approx) subscriptions continuing, $5,000; assured total, $12,737.42.

Mr. Lewis stated that the five-year period for which the laboratory had originally been financed had now expired. With sufficient backing of the membership the work could be continued. Otherwise refinancing looked like a most difficult task. The committee was strongly in favor of the research work, but did not propose to continue unless assured of adequate backing.

Laboratory Excites Extraordinary Discussion

In order to bring the matter properly before the meeting, a motion was immediately made by Walter S. Timis and seconded by H. M. Hart, that the Research Laboratory be closed owing to the lack of funds. The discussion on this motion lasted the rest of the session and extended over to the next day. From the large number who took part in the discussion and the intense interest manifested, it was evident that the seriousness of the proposal was fully realized.

Space does not permit outlining the many viewpoints presented by those who discussed this motion, but the general trend of opinion was as follows: In the first case it appeared that practically all present felt that the work done by the laboratory had been of great importance. Some thought that not enough stress had been laid on practical applications, that the fundamental work done, while of immense future value, did not enable the manufacturers who had contributed to get an immediate return for their money. This would make refinancing difficult.

Others contended that the work paid extremely well. The chief difference of opinion centered on the possibility and methods of raising the necessary money. Throughout this discussion a strong undercurrent of loyalty and enthusiasm for the laboratory was apparent. This finally broke forth in a series of unsolicited offers which totaled $4,800 in a few moments, and would evidently have reached a much larger sum had not this movement been stopped by the statement that the meeting was not to raise money but to get the sentiment of the society. Representatives of the manufacturers, in particular, showed great appreciation of the work of the laboratory and their willingness to support it.

The research committee felt that in any case the laboratory should not continue to operate on the old plan, and made the following recommendations (presented here in outline only):

1. That the restriction on research for compensation be rescinded.

2 and 3. That the society raise $10 per member for laboratory overhead and fundamental research.

4. That research on approved subjects may be undertaken for outside organizations where funds are assured.

5. That where such tests are undertaken for a manufacturer, he shall pay all costs including overhead, that the results be published first and without comment in the *Journal*.

6 and 7. That technical subcommittees shall be appointed to consult with the laboratory on specific projects and to report to the research committee.

The discussion of these resolutions raised the suggestion that an attempt be made to secure an endowment of from $500,000 to $1,000,000. As a final outcome of the discussion the motion to shut down the laboratory was defeated and the recommendations of the committee were accepted. In both cases the vote was enthusiastic and practically unanimous.

The endowment suggestion led to a motion that the feasibility of such an endowment be investigated, and that a report be submitted at the summer meeting. This was carried.

New Code for Heating and Ventilation

The following were elected members of the committee on Research for a term of three years to succeed those members whose terms have expired: Homer Addams, E. Vernon Hill, Arthur Kellogg, J. R. McColl and F. R. Still.

Other business handled included a report on the new proposed Code of Minimum Requirements for the Heating and Ventilation of Buildings. Preliminary drafts of the code were distributed and discussed. It is proposed to submit a revision for final approval at the summer meeting. This code, the preparation of which has involved an enormous amount of work, is in fourteen sections, each handled by a separate subcommittee. The subjects covered are in brief, as follows:

I—Definitions and Scientific Fundamentals; II—Ventilation Requirements for Public Buildings; III—Estimating Heat Required for Warming Buildings; IV — Determination of Amount of Direct Radiation Required; V—Determination of Amount of Indirect Radiation Required; VI—Capacity and Installation of Low-pressure Steam and Hot-water Boilers; VII—Design and Installation of Warm-air Furnace Plants; VIII—Flues, Breechings, Stacks, etc.; IX—Pipe Sizes for Low-pressure Steam, Vapor and Vacuum Systems; X—Pipe Sizes for Hot-water Heating Systems; XI — Air-Ducts, Fans, etc.; XII—Air Washers and Filters; XIII—Condensation Return Pumps; XIV—Standard Symbols for Drawings. These were discussed section by section and approved tentatively with suggestions for changes.

Comments on New York Report

The committee appointed for the purpose submitted its report commenting on the report of the New York State Commission on Ventilation. While complimenting the state committee on its conscientious work, regret was expressed that the report did not get down to the scientific fundamentals. Heating and ventilating engineers were prepared to produce any desired set of conditions if these conditions could be scientifically defined in terms of temperature, humidity, oxygen content, air movement and presence of injurious substances. The committee's report was unanimously approved.

The Kansas City Chapter presented the advantages of that city as a convention center and urged the Society to hold its summer meeting there. A total registration of 389 at the annual meeting was announced. The membership committee announced a net membership increase of 36 per cent, the present membership being 1,862.

Speaking for president F. R. Low, who was unable to be present, Charles E. Gorton presented the best wishes of the A.S.M.E. and congratulated the society on the splendid co-operative spirit exemplified in the work on the Code for Heating Boilers. He suggested that the next annual meeting be held at about the same time as the Power Show and the annual meeting of the A.S.M.E. He also mentioned the possibility of co-operation in securing reduced railway fares.

It was then announced that C. W. Obert, who for eight years has been secretary of the organization, had submitted his resignation. A resolution in appreciation of Mr. Obert's work was unanimously passed. Mr. Obert thanked the Society for its continued support and expressed his desire to continue in close contact with its work.

The installation of new officers concluded the session. In assuming his new duties as president, Mr. Addams commented on the remarkable development of the Society during the office of his predecessor, Mr. Gant. He expected that in another eight years the membership would reach 6,000.

Economy of Fuel Through Intelligent Operation*

By H. H. Norton
Lieut-Comdr. U. S. Navy

MANY times have I heard the question asked, "In what manner can the efficiency of a plant be most expeditiously increased?" Although there are numerous specific methods that might apply to a particular plant, there is generally one method that pertains to all. This is the saving that can be made as the result of intelligent operation in the generation of power necessary to operate the plant.

As the combustion of fuel applied to a boiler for the generation of steam is the most common method of supplying power for a plant, intelligent operation in firing in order to generate the steam is a subject of paramount import.

The Navy Establishes a Fuel Oil Testing Plant

The Navy is a noteworthy example of an organization which has recognized the necessity of skillful operation in effecting economy. The advantages of fuel oil, particularly for marine purposes, could readily be seen, but the full benefits expected were not readily obtainable. To ascertain why they were not obtained, was the direct cause of the establishment by the Navy of a fuel-oil testing plant.

This plant was started about the time that the first oil-burning installations afloat were completed, but was not of great value until the year 1911, about a year after the operation afloat had shown its necessity. To remedy conditions afloat was its first mission, but later on it became an experimental plant for improvements as well as a testing plant of established methods.

It is interesting to note, among other things, that boiler efficiencies with oil-burning installations for the last ten years have, for the same rates of combustion, increased 10 per cent, and in some cases more than this. To date the highest boiler efficiency recorded at the fuel oil testing plant under test, *without* the use of preheated air, is very close to 84 per cent. Boiler tests in 1911 and 1912 show efficiencies ranging from 64 to 75 per cent with an average of about 70 per cent. While this increase in efficiency must be mainly accounted for by the improvements in apparatus, some of it should nevertheless be credited to more skillful operation.

Eighty per Cent Boiler Efficiency at One Hundred per Cent Rating

As a result of experience with many types of boilers, I believe there is little excuse for operating in a manner that produces less than 80 per cent boiler efficiency at a 100 per cent boiler rating, nor should there be a drop of more than 1 or 2 per cent efficiency per 100 per cent increase in boiler rating. The operating engineer who is obtaining 80 per cent boiler efficiency is doing well and must observe his operation very closely for each additional one per cent when striving for the maximum. But the one who is not obtaining 80 per cent could, with more intelligent operation, easily bring the efficiency to this figure.

It was the fact that results being achieved by the Navy under test conditions were not being duplicated in practice, that led the Navy to realize that the man who superintends or actually fires the boiler must be instructed as to the proper method. To accomplish this, competition and, later, education, were the means employed. Competition instilled a desire which at times proved very costly, until education was included.

The Shipping Board, following the steps of the Navy, is also steadily increasing efficiency in this line, and a larger percentage of this increase is attributed by them to the education of their operating engineers.

Cost of Fuel Is a Major Operating Expense

Regardless of the type of plant maintained by any industrial concern, the cost of fuel is directly or indirectly a major operating expense. Fuel saved is money earned. But does the man who by his position is most concerned about the earnings of a company, know anything about the economical use of fuel? He is doubtless in a position to receive the ablest kind of engineering advice as to apparatus, but would he be inclined to spend money on the education of his operating force in such a manner as the Navy does? His adviser can probably state that he has seen certain results obtained from an apparatus under test conditions, but when he tries to operate a duplicate installation he does not always reproduce the test results. When this occurs, is consideration given to the fact that the skilled personnel who conducted the original test were not in themselves duplicated?

What percentage of the cost of an apparatus is spent in educating its future operating force? A large percentage of your expenditures may go toward purchasing equipment and fuel, and if the opportunity arises to cut down the fuel bill a small percentage by purchase of additional equipment, it is generally done; but how much effort is spent with the means at hand through intelligent operation? On one hand, with skillful operation there is but a small percentage to work on to obtain the highest theoretical efficiency; whereas on the other, if operation is unskillful, there is a much larger percentage to work upon to achieve a saving at little expense.

By referring to the theory of combustion, it is not meant that it is necessary for every fireman to be educated to the point where he can figure out the boiler efficiency or strike a heat balance, but rather to where he knows the constituents of his fuel and the necessity for the combination of the combustible with just sufficient quantity of air to convert it completely to the gases that are the products of complete combustion. He should realize that the carbon, hydrogen and sulphur must receive sufficient air to be converted to carbon dioxide, water and sulphur dioxide, in order that the total number of potential thermal units in the fuel be abstracted; that insufficient air will cause the formation of carbon monoxide, and that when carbon monoxide is formed the amount of heat obtained from the carbon of the fuel is only about one-third of what it would be were the carbon converted to the dioxide.

He should know that smoke is unburned carbon, representing great loss of heat and consequently money—not only for the reason that the carbon leaving the furnace as smoke produces no heat and dirties the heating surfaces, but is also usually accompanied by carbon monoxide. He should also be cognizant to the fact that if more air is supplied than is absolutely necessary to convert the carbon to carbon dioxide, and the other constituent elements to their respective gases, the excess will dilute the hot furnace gases and it will be necessary to expend much heat to raise the excess air to stack temperature; that the sooner a complete mixture of the fuel with air can be effected, the more chance the gas will have to give up its heat before escaping to the atmosphere; and that the lower the temperature of the gases escaping from the stack, the more heat has the boiler absorbed for the generation of steam.

These items together with knowledge of the instruments necessary to indicate the quality of combustion, should result in a majority of cases in a greater saving in the fuel bill than any other means.

*Extract of paper presented before the Engineers' Club, Philadelphia, Pa., Jan. 15, 1924.

Large Utility Financing in California

During the last calendar year the State Railroad Commission of California authorized public utilities operating in the state to issue securities in a total amount of $196,803,435.79, the largest sum of any year excepting 1914, when one of the steam-railroad systems was permitted to swell the normal total by more than $50,000,000 in bonds. In 1923 the electric companies, including gas interests, were permitted to issue bonds, stocks, notes, etc., for $92,780,007.91. The largest amounts of the individual companies were: Pacific Gas & Electric Co., $3,593,231 in stock and $20,000,000 of bonds; Southern California Edison Co., $5,000,000 stock and $21,908,000 bonds; Great Western Power Co., $4,000,000 stock and $1,000,000 bonds; San Joaquin Light & Power Corp., $2,433,000 bonds; Los Angeles Gas & Electric Co., $8,000,000 bonds; San Diego Consolidated Gas & Electric Co., $1,118,000 stock and $1,438,000 bonds; and the Southern California Gas Co., $1,000,000 in stock and $2,500,000 of bonds.

Pinchot Coal Bill Introduced Into Congress by Borah

Senator Pepper of Pennsylvania Refused To Present It—Bill Thought To Be Constitutional

SENATOR BORAH, of Idaho, on Jan. 24, introduced in the Senate the coal bill drafted at the instance of Governor Pinchot, of Pennsylvania. While Senator Borah told the Senate on introducing the bill that he had not had an opportunity to study its details, he did declare that he is in thorough sympathy with the object and purpose to be attained by proper legislation along the lines indicated by this measure.

"The coal situation," asserted the Idaho Senator, "is a very serious one and, in my judgment, one with which Congress ought to deal. The bill ought to go to the committee so that those who are in favor of it may be given an opportunity to urge it. After full examination, I may find myself in perfect accord with the entire measure."

The bill is of unusual interest to legislators in that it is recognized as being the most competently and carefully prepared measure that has come before Congress. Numerous proposals to regulate the coal industry have been introduced, and some have been considered at great length, but without exception these measures have been more or less crudely drawn. There is every evidence that this is the product of capable talent.

It is quite apparent that the drafters of the bill gave much attention to the decision of the Supreme Court of the United States in the Kansas Industrial Court case. In that opinion the court made it perfectly plain that the power to regulate turns on a question of fact, which is whether or not the public would be subjected to exorbitant and arbitrary control if there were no arbitrary regulation.

The Pinchot bill uses almost the exact language of that decision. It does not give the proposed coal division of the Interstate Commerce Commission power to fix prices and margins except "where in the absence of such regulation there exist exorbitant and arbitrary charges or there is danger thereof to the public." The coal division can issue an order of that sort only after having conducted hearings and studied the particular situation so as to establish certain facts. Even in cases where the Commission may decide that power resembling monopoly is being exercised, its order is subject to review by the courts and holds only if the court sustains the finding of fact. This is a new formula quite different from that applied by the Lever law. It is regarded quite generally as being an ingenious formula. The regulation of prices under such a plan might not be effective, but the first impression in Washington is that the plan is constitutional.

Bill To Establish Foreign Commerce Service

There has been introduced into the House of Representatives by Mr. Wilson, of Massachusetts, a bill to establish in the Bureau of Foreign and Domestic Commerce a "Foreign Commerce Service" of the United States, which will consist of officers to be graded and known as commercial counselors, commercial attachés, assistant commercial attachés, trade commissioners and assistant trade commissioners to be selected under civil-service regulations to promote foreign commerce by investigation, inspections, reports, etc. The bill is designed to stabilize the service and to make it more efficient, economical and effective. Heretofore the service has been without civil-service requirements and the appointments to stations subject to change and uncertainty.

Amendments to United States Water-Power Act Discussed

Proposed amendments of the water-power act were discussed at a meeting of the Federal Power Commission Jan. 25. The commission is ready to support actively the amendments proposed by O. C. Merrill, which propose: To bring under the act plants operating under federal permits issued prior to the passage of the water-power act; to provide authorization for the hiring of personnel instead of utilizing the services of employees borrowed from the War, Interior and Agriculture Departments; to give the Commission authority to use the funds collected from

Marine Engineer's Beneficial Association in Convention at Washington

This photograph was received too late to be included in the report of convention published in last week's issue.

licensees to apply on its operating expenses; to co-ordinate under the Federal Power Commission various activities of the three departments in which power is the principal interest.

The Commission also discussed the proposal of Senator Ralston, of Indiana, that the jurisdiction of the Commission be extended so as to include all streams in what formerly was Northwest territory. Under an old act all streams capable of floating a canoe in the area north of the Ohio and East of the Mississippi were designated as public highways. This was done in the interest of the hunting and trapping industry of that day. Under the act, the Indiana senator contends that the Federal Power Commission now can take jurisdiction. His purpose is to bring all water-power projects under the water-power act and subject them to the recapture provision.

Fourth Offer for Muscle Shoals Submitted

Just before the hearings of the Military Affairs Committee of the House of Representatives on the Muscle Shoals propositions closed, E. H. Hooker, the president of the Hooker Electrochemical Co. of Niagara Falls, on behalf of himself, Gen. W. W Atterbury, vice-president of the Pennsylvania Railroad Co., and J. G. White, head of the White Engineering Co., of New York, submitted the fourth offer in connection with the Muscle Shoals properties. The Hooker offer proposes the formation of a company in which the United States will own 75 per cent of the stock. The company is to operate the water power and the nitrate plant. As an evidence of good faith Mr. Hooker and his associates will contribute an operating fund of $1,000,000. During the first ten years they are to receive 2.66 per cent of the profits of the operation and after that 2 per cent, the balance to go to the government. They agree to set aside certain sums for research purposes and contend that their offer from a dollar and cents viewpoint is more advantageous than any one of the others. Mr. Hooker is president of the Manufacturing Chemists' Association. He told the committee that over a fifty-six-year period, without computing interest, the Ford offer would return $70,000,000 to the government. The offer of the associated power companies, he said, would return to the government $159,000,000. The offer which he presented, he declared, would return to the government at least $260,000,000, with a possible maximum of $500,000,000.

A trend away from the Ford offer was exerted to some extent by the refusal of Mr. Ford to appear before the committee, but the real force behind the change of position was the appearance of representatives of farmers, manufacturers and chambers of commerce, representing states in the Muscle Shoals' region, who urged the utilization of the power for public utility uses rather than for manufacturing at Muscle Shoals.

The committee closed its hearings on Tuesday with the four offers—the Ford proposal, the Southern power companies,' the Union Carbide Company's and the Hooker Electrochemical Company's—before it. On Wednesday it proceeded to the consideration of the McKenzie bill, which is a pro-Ford measure.

Engineers Have Improved Employment Service

The National Engineering Societies have for many years maintained "engineering employment clearing houses," but because of lack of sufficient funds these have not attained the status of a national service. Within the last few months the employment service operated under the joint supervision of these national societies has inaugurated a policy calculated to insure the needed funds to provide a truly national service, with offices in leading cities throughout the country. Under this policy the societies continue their financial support, and this is supplemented by contributions from those deriving benefit from this enterprise, as no profit to anyone is to be taken, simply a self-supporting service. Contributions if on a basis of but 25 per cent of the fees that must be necessarily exacted by a commercial agency, will make possible the realization of a national service

With the new plan fully developed, representatives of the employment service will visit those with positions available, to get first-hand information as to the requirements of the job.

Over 55,000 engineers, including the most prominent of the profession, are members of the societies conducting the service, thereby insuring employers a selection from engineers of known antecedents and whose records have been closely scrutinized, thus automatically providing employers with facilities of unique extent.

Engineers seeking opportunities may arrange to obtain weekly by first-class mail the current list of openings. Their availability is also announced in the respective publications of the Engineering Societies.

World Power Conference Program and Entertainment Plans Maturing Rapidly

Noted Americans To Address Conference—Delegates To Sail on "Scythia" from New York June 19, Boston June 20

THE WORLD Power Conference, June 30 to July 12, with subcommittees in all of the leading countries of the world, is rapidly shaping plans for the program and entertainment of its delegates and guests. The United States having most extraordinary experience in the development of all manner of power has arranged a most comprehensive program and has secured the leading authorities in America to prepare papers. Among these are Samuel Insull, John R. Freeman, W. M. White and H. B. Taylor, Dr. D. S. Jacobus, F. G. Baum, W. S. Murray, Charles T. Main, Owen D. Young, O. C. Merrill, A. P. Davis, Peter Junkersfeld, George A. Orrok and J. W. Lieb.

An attractive program of functions to be held in London in connection with the Conference will include Conversazione by the Joint Societies at Albert Hall, the Kelvin Centenary Celebration beginning July 9 with an oration at Wembley Park, reception at the Royal Society July 10, banquet July 11 and the presentation of the Kelvin medal to Dr. Elihu Thomson and special service at Westminster Abbey and St. Paul's. Special trips will be made by the various participating societies to near-by points of attraction. Following these events there will be tours in Great Britain, France, Switzerland, Italy, Scandinavia and Lapland. Special emphasis will be given to visits to power plants and developments in these several countries, and in each country the tour will be under the auspices of the Committee of the World Power Conference of that country. Czechoslovakia is hoping to arrange a conference on scientific management and possibly technical education.

The delegates to the World Power Conference their families and friends are planning to sail on the Cunard steamer "Scythia," 20,000 tons, leaving New York City on June 19 and Boston on June 20, arriving in Liverpool on June 28. Thomas Cook & Son, 51E Fifth Ave., New York City, with branches in other cities, have been appointed by both the British and American Committees of the World Power Conference official transportation agents. In addition to the steamer accommodations Thomas Cook & Son have secured a large selection of accommodations at London hotels and are also arranging a series of tours in Europe, both technical and scenic, for travel both before and after the conference.

Research Council Plans Study of Heat Transfer

In a meeting held at the Engineering Societies Building, New York City, Jan. 29, and attended by about forty engineers and scientists, the National Research Council expressed its willingness to administer a broad investigation of the subject of heat transfer, if suitable backing, including talent, facilities and funds, could be assured. It is felt that the first step is to make a critical study and digest of all the work done to date on the subject. This has been carried on by many investigators, and in many fields. Some of it is valuable and some worthless, while some contains good material in unavailable form. On account of the immense importance of the subject of heat transfer in such diverse branches as steam engineering, refrigeration, electrical engineering, chemical engineering, etc., the Engineering Division of the National Research Council agrees that reliable guidance in this matter is perhaps the greatest technical need of the engineering profession at the present time.

The matter was discussed by repre-

sentatives of various research laboratories, manufacturers and large power companies. It was voted to accept the offer of the National Research Council to furnish administrative guidance and lend its prestige to the project. The meeting delegated to Mr. Spraragen, secretary for the National Research Council, the selection of an executive committee to study the needs of the situation, formulate a plan of action, and be responsible for its execution. An important part of the work of this committee will doubtless be the securing of the necessary funds, talent and facilities for the work. The meeting expressed its desire that the executive committee immediately appoint two other committees of technical experts, one to deal with heat insulation and the other with cases where the transfer of heat is desired.

Rent Demanded for New York State Water

Steps to force the Niagara Power Co. to pay rental to New York State for the use of 4,400 cu.ft.-sec. of water that goes over Niagara Falls are expected to follow action taken by the New York Water Power Commission in referring the matter to a committee composed of Attorney General Sherman, State Engineer La Du and Speaker Machold of the General Assembly. Up to the present time the company has paid nothing for use of this water, which represents the last that can be utilized under existing treaty between the United States and Great Britain. Company officials are said to have declared a rental charge would have to be met by a rate increase.

N. Y. City to Amend Charter for Operating Engineers

A bill has been introduced into the New York State Assembly to amend the Charter of Greater New York in relation to engineers and the operation of steam boilers. The bill would add the following qualification to the appointee as examiner: "The Commissioner (Police) shall appoint as such examiner (for operating licenses) civilian practical engineers who shall for at least ten years have held an engineer's license or certificate issued by the police department. Such civilian employee shall be under the control of the lieutenant of police of the City of New York in charge of the sanitary company. An applicant who takes an examination for an engineer's license or certificate shall pay the sum of one dollar and for each transfer of engineer's license or certificate shall pay the sum of fifty cents. All sums so charged and collected pursuant to this section shall be and remain the property of the City of New York."

A Correction

In the article "Barge Power Plant for Municipal Service," which was published in *Power*, Jan. 8, the weight of the temporary power plant in the Columbia River at Longview Millsite, the weight of the equipment was erroneously given as 55 tons. The plant weighs 250 tons.

Coming Conventions

American Boiler Manufacturers Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Annual winter meeting at Hollenden Hotel, Cleveland, Ohio, Feb. 12.

American Ceramic Society. Ross C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Atlantic City, Feb. 4-8.

American Electrochemical Society. C. G. Fink, Columbia University, New York City. Meeting at Hotel-Bellevue-Stratford, Philadelphia, Pa., April 24-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at the Bellevue-Stratford Hotel, Philadelphia, Feb. 4-8. Spring convention at Birmingham, Ala., April 7-10.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 18-21.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29, formerly announced, May 19-22.

American Water Works Association. J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

Association of Iron and Steel Electrical Engineers. W. M. Chandler, 708 Empire Building, Pittsburgh, Pa. Fuel Saving Conference—Combustion Engineers. April 2-3.

Indiana Engineering Society. Charles Brossman, 1503 Merchants Bank Bldg., Indianapolis, Ind. Annual meeting at Lincoln Hotel, Indianapolis, Ind. Feb. 14-15.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Kansas Association** at Parsons, Kans., April 16-18. J. M. VanSant, 739 Horne St., Topeka, Kans. **Indiana Association** at La Fayette, Ind., May 5-6. Prof. A. W. Cole, Purdue University, Lafayette, Ind. **New Jersey Association** at Newark, June 6-8. Joseph P. Flynn, 16 Palmer St., Elizabeth, N. J. **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Waterhouse Block, Cedar Rapids, Iowa. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at Bridgeport, Conn., June 27-28. George F. Klopfer, 30 East Pearl St., New Haven, Conn. **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass.

National District Heating Association, D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 11-14, 1924.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Buffalo, N. Y., April 30 to May 2, 1924.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

Society Affairs

The Louisville, (Ala.) Section of the A.S.M.E. will at its Feb. 12 meeting at the Engineers and Architects Club, hear Lloyd Greenbaum of the Reed Air Filter Co. speak on "Dust Removal from Air and Air Filters."

The New Britain (Conn.) Section of the A.S.M.E. will have as the topic of its Feb. 21 meeting "Belting and Belt Transmission," illustrated by lantern slides. Louis W. Arny of the Leather Belting Exchange will be the speaker.

The American Society of Heating and Ventilating Engineers recently appointed F. C. Houghten, formerly with the Society's staff at the Research Laboratories at Pittsburgh, as secretary of the Society. He will assume the office on Feb. 4.

The Meriden (Conn.) Section of the A.S.M.E. will hear F. C. Langenberg, director of laboratories, Watertown Arsenal, speak on "The Results of a Test to Determine the Effect of Temperature on the Shock Resisting Properties of the Various Compositions of Steel," at the Home Club on Feb. 20.

The Technical Section of the New England Division of the N.E.L.A. will be addressed by W. L. R. Emmet, consulting engineer of the General Electric Co. at the Copley Plaza Hotel, Boston, Mass., Feb. 11, upon "The Mercury Turbine." The meeting will start at 10:30 a.m. and will include a luncheon with provision for discussion of technical problems in the afternoon. A. H. Sweetnam, 39 Boylston St., Boston, Mass., is chairman of the Section.

Business Notes

C. W. Whiting, consulting engineer, announces a change of address from 148 State St. to Park Square Bldg., Boston, Mass.

C. L. De Forge, for many years chief engineer of Plant No. 1, Montpelier & Barre (Vt.) Light & Power Co., has been transferred to the company's Plant No. 3 as construction foreman and has been replaced by D. C. Barney.

Lawrence D. Kingsland, 2nd, has been appointed engineer in the hydraulic division of Stone & Webster, Inc., Boston, Mass. Mr. Kingsland was formerly with the Foundation Co. engaged in water supply work at Lima, Peru.

Obituary

James F. Cleary, an engineer in the Power Station Betterment Division of Stone & Webster, Inc., Boston, Mass., died on Jan. 20 at his home near Boston.

John Donnelly who was chief engineer of the Westmount Light & Power Co., Westmount, Province of Quebec, and near the City of Montreal, died on Jan. 24 at Montreal in his 69th year. Mr. Donnelly, who was born and educated in Montreal, had been employed as chief engineer for the power company from 1908 to 1923.

Business Notes

The Standard Turbine Corp., Scio, N. Y., announces the opening of a San Francisco office, the representative being Halloran & Golcher. It also announces the opening of an Omaha, Neb., office, the representative being the Industrial Sales & Engineering Co.

The Conveyors Corporation of America, 326 West Madison St., Chicago, Ill., announces that the new firm of Lathrop & Trotter, 733 Union Trust Bldg., Cincinnati, Ohio, is to be the Cincinnati representatives of the corporation.

The Linde Air Products Co., 30 East 42d St., New York City, manufacturers of oxygen for welding, etc., announces that Robert W. White, formerly assistant general sales manager, has been appointed general sales manager of the Carbide and Carbon Chemicals Corp. L. M. Zimmer, Western sales manager, will succeed Mr. White. E. E. Radcliffe has been appointed assistant sales manager, and F. E. Stoppenbach, district sales manager of the Eastern division, with offices in New York City. Herman Ullmer has been appointed assistant sales manager, Western division, and will be located in Chicago.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Jan. 21, 1924	Jan. 28, 1924
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.25	2.25
Clearfield	Boston	2.25	2.25
Somerset	Boston	2.50	2.50
Kanawha	Columbus	1.75	1.75
Hocking	Columbus	2.00	2.00
Pittsburgh No. 8	Cleveland	2.00	2.00
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.75	2.75
West Ky.	Louisville	1.75	1.75
S. E. Ky.	Louisville	2.00	2.00
Big Seam	Birmingham	1.85	1.85

FUEL OIL

New York—Jan. 31, light oil, tank-car lots, 28@34 deg. Baumé, 4½c. per gal., 36@40 deg. 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Jan. 22, tank-car lots, f.o.b. St. Louis; 24@26 deg.. $1.95 per bbl.; 26@28 deg., $2.00; 28@30 deg., $2.05; 32@36 deg., gas oil, 5½c. per gal.; 36@40 deg., distillate, 5¾@6c. per gal.

Pittsburgh—Jan. 31, f.o.b. local refinery, 30@34 deg., fuel oil, 5½c. per gal.; 36@40 deg., fuel oil, 5½c.; 34 deg., neutral 8½c. per gal.

Dallas—Jan. 25, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Cincinnati—Jan. 29, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 5½c. per gal.; 30@32 deg., 6c.; 38@42 deg., distillate, 7c. per gal.

Philadelphia—Jan. 25, 28@30 deg., $1.78½@$1.82½ per bbl.; 18@22 deg., $1.62½@$1.66½; 13@16 deg., $1.47@$1.51½ per bbl.

Boston—Jan. 28, tank-car lots, f.o.b. heavy oil, 12@14 deg Baumé, 4⅝c. per gal., light oil, 28@32 deg. Baumé, 6⅝c. per gal.

Chicago—Jan. 19, 24@26 deg., $2.12 per bbl.; gas oil, 32@36 deg., 4.93c. per gal.

New Plant Construction

Ala., Birmingham—The Birmingham Engine & Machinery Corporation is making inquiries for two Corliss engines, 16 x 36 in. and 24 x 48 in., with auxiliary equipment.

Ala., Brewton—The Brewton Veneer Co., has tentative plans under advisement for the rebuilding of the portion of its mill and power house recently destroyed by fire with loss approximating $50,000.

Ark., Altheimer—The Board of Improvement plans for the installation of electric-operated pumping machinery in connection with extensions and betterments in the municipal waterworks.

Ark., Little Rock—The Arkansas Bauxite Products Co., 313 Donaghey Building, C. D. Hyten, president, plans for the construction of a steam power plant at its proposed mill on tract of land recently leased, estimated to cost $40,000.

Ariz., Phoenix — The Salt River Valley Water Users' Association plans for the construction of a series of electric-operated pumping stations in connection with the installation of an irrigation system for the Roosevelt Agricultural Improvement District, which has voted $665,000 for the project.

Calif., Azusa — The Azusa Water Co. plans for extensions in its distributing system between Covina and Baldwin Park, to include the installation of electric-operated pumping equipment. A fund of $100,000 is being arranged for the work.

Calif., Coalinga—The Midland Counties Public Service Co., has plans under way for extensions in its power plant to cost in excess of $150,000, including the installation of additional equipment.

Calif., Corcoran — The Board of City Trustees has authorized the installation of new pumping machinery for the municipal water system.

Calif., Petaluma—The City Council plans for the construction of a pumping plant in connection with a new sewerage system. Lyman Creek is city clerk.

Calif., San Diego — J. R. Showley, 825 Eighth Street, manufacturer of confectionery, plans for the construction of a power house in connection with a new plant to replace a factory recently destroyed by fire. It is estimated to cost about $250,000.

Conn., New Haven—The Hygienic Ice Co., has preliminary plans under way for the erection of an addition to its ice-manufacturing plant. A portion of a bond issue of $200,000, now being arranged, will be used for the expansion. A list of machinery to be installed will soon be prepared.

D. C., Washington—The Board of District Commissioners has approved a bill submitted by the House District Committee, providing for the construction by the Government of two hydro-electric power plants on the Potomac River at Great Falls and near Chain Bridge, respectively, to cost $18,616,000 and $13,600,000, in order noted, for service in the District and vicinity. The project also includes storage reservoirs to cost $13,000,000.

Fla., Sanford—The Common Council is disposing of a bond issue for $310,000, the proceeds to be used for the installation of a municipal electric power plant, recently voted at a special election.

Idaho, Gem.—The Gem Irrigation District has approved a bond issue of $450,000, the proceeds to be used for the construction of a hydro-electric power plant at the Black Canyon dam. Plans will soon be prepared.

Ill., Chicago—The Department of State Welfare, Capitol Building, Springfield, will build a one-story power house at the University of Illinois, 1820-22 West Taylor Street, in connection with other structures, for which bids are being asked on a general contract. E. A. Martin, 306 South Wabash Avenue, Chicago, is architect.

Ill., Chicago—The Egan Ice Co., has filed plans for the erection of a one and two-story ice-manufacturing plant, 138 x 165 ft., at 5929-41 East Ravenswood Avenue, to cost about $40,000.

Ill., Chicago—A boiler, engine and pumping plant will be installed in the six-story and basement factory, 125 x 200 ft., to be constructed at Belmont and Harding Avenues, by the Florsheim Shoe Co., 541-71 West Adams Street, estimated to cost $675,000, for which bids will be taken at once on a general contract. Alfred S. Alschuler, 28 East Jackson Boulevard, is architect and engineer.

Ill., Evanston—The Consumers Co., 111 West Washington Street, Chicago, Ill., has plans nearing completion for the construction of an ice-manufacturing plant, 130 x 240 ft., at 1336 Dodge Avenue, estimated to cost $200,000. Walter J. Malatesta is vice-president.

Iowa, Hazelton — The Common Council plans for the installation of an electric-operated pumping station in connection with a proposed municipal water plant. A. L. Nelson is city clerk.

Iowa, Madrid—The Brown Artificial Ice Co., is having plans prepared for the erection of a new plant to cost about $28,000. W. L. and E. H. Brown head the company.

Iowa, Mapleton — The Common Council will have plans completed for a municipal power plant, lately held in temporary abeyance through a court injunction, which has been dismissed. R. H. Morrison is town clerk.

Iowa, Pisgah — The Common Council is arranging a bond issue for the construction of a municipal lighting plant, for which plans will soon be prepared.

Kan., Independence—The Crystal Ice & Fuel Co., has tentative plans under advisement for the construction of a one-story ice-manufacturing plant, 60 x 105 ft., designed to carry two additional floors later, estimated to cost $55,000. A. B. Shaffer is general manager.

Kan., Kansas City — The City Council, Howard Payne, city clerk, is planning to call for bids at an early date for one 10-in., four 20-in. and three smaller vertical pumps, with motors and controls; also, for a 60 hp. motor, control and chain drive, and other similar equipment.

Kan., Sterling—The Common Council is planning for the installation of electric-operated centrifugal pumping equipment at the waterworks, with additional boilers, tank and tower, and other apparatus. The Ruckel Engineering Co., Interurban Building, Hutchinson, Kan., is engineer.

La., Bogalusa—The Union Bag & Paper Corporation, Woolworth Building, New York, N. Y., is reported to be planning for the construction of a power house at its proposed local plant for the production of paper containers, etc., estimated to cost in excess of $150,000.

La., New Orleans — The New Orleans Public Utilities Co., has preliminary plans for an addition to its local power plant, to include the installation of a 20,000 kw. generator, and auxiliary machinery. The work will be carried out in connection with an expansion program for the present year, to involve approximately $5,000,000.

Me., Knightville — The Cumberland County Power & Light Co., 453 Congress Street, Portland, Me., is planning for the construction of an addition to its steam-operated power plant to cost about $1,000,000. The capacity will be increased by about 12,500 kw.

Mass., Lowell—The Lowell Electric Light Corporation has tentative plans under advisement for extensions in its power plant, in connection with an expansion program for the present year.

Mass., Somerset—The Montaup Electric Co., 85 North Main Street, Fall River, Mass., R. F. Whitney, president, is completing plans and will soon break ground for the construction of its proposed steam-operated electric generating plant, on site

recently acquired, to cost approximately $6,500,000. Stone & Webster, Inc., 147 Milk Street, Boston, is engineer.

Mich., Detroit—The General Necessities Corporation, 900 Park Avenue Building, has preliminary plans under advisement for the construction of an ice-manufacturing plant at West Fort and Lawndale Avenues, with cost reported at close to $90,000.

Mich., Pequaming—The Ford Motor Co., Highland Park, Detroit, is considering the construction of a steam-operated power house at its proposed local saw mill and woodworking plant, reported to cost in excess of $150,000. The project will mature early in the spring.

Minn., Duluth—Walter Whiteside, 404 Atlas Building, Tulsa, Okla., and associates, are having plans prepared for the construction of a hydro-electric power plant on the Cloquet River, north of Duluth, to cost in excess of $500,000, with equipment. A. Hanford, Sellwood Building, Duluth, is architect.

Minn., Little Falls — The Itasca Paper Co., Grand Rapids, Minn., plans for the construction of a power house at its proposed local paper mill, on site recently acquired, estimated to cost in excess of $400,000.

Minn., New Prague—The Common Council has tentative plans under consideration for the construction of a municipal electric plant. J. F. Brusek is city clerk. An engineer will soon be selected.

Minn., Willmar — The Common Council has commissioned Toltz, King & Day, Inc., Pioneer Building, St. Paul, Minn., engineer, to prepare preliminary plans for a municipal power plant, to cost about $125,000.

Mo., Joplin—The Rialto Mining Co. has tentative plans for the installation of an air compressor and auxiliary equipment at its No. 2 mill. S. G. Ash is superintendent.

Mo., Moberly—The Polar Wave Ice & Fuel Co., 3626 Olive Street, St. Louis, Mo., will commence the construction of a local ice-manufacturing plant, for which a general contract has been let to Bell Brothers, Moberly. It is estimated to cost close to $50,000.

Mo., Moberly — The Todd Demountable Rim Mfg. & Sales Co., care of J. W. Lynch, head, Windsor Place, plans for the construction of a power house in connection with its proposed local plant, estimated to cost $80,000.

Mo., Thayer—The Common Council has commissioned the Alexander Engineering Co., Woodruff Building, Springfield, Mo., consulting engineer, to prepare plans for the proposed municipal ice-manufacturing plant and waterworks, for which bonds for $75,000 have been approved.

Mont., Missoula — The City Council has engaged the Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., engineer, to prepare plans for the proposed municipal waterworks to cost about $900,000, to include power house electric-operated pumping machinery and auxiliary equipment.

Neb., Lincoln—The State Board of Control, E. B. Fairfield, secretary, will take bids until Feb. 18, for the installation of a refrigerating plant at the Lincoln state hospital.

Neb., University Place—Cecil C. Gates, city clerk, will receive bids until Feb. 15, for two 500 g.p.m. motor-driven centrifugal pumps, high lift pumping station, valves, hydrants and other equipment for a municipal waterworks. Grant, Fulton & Letton, Bankers' Life Building, Lincoln, Neb., are engineers.

Neb., Walthill—The Common Council is having plans prepared for its proposed municipal electric plant and ice plant, and will take bids early in the spring. Bonds for $45,000 have been approved. The Prince-Nixon Engineering Co., Peters Trust Building, Omaha, Neb., is engineer.

N. J., South Amboy—The City Council is discussing the advisability of installing a municipal electric power plant. Edwin L. Tice, councilman, is at the head of the enterprise.

N. Y., Elba—The Elba Cold Storage Co., 535 East Ferry Street, Buffalo, Frederick Stevenson, president, will take new bids at once on revised plans for the erection of its proposed two-story cold storage plant on local site, 100 x 142 ft., estimated to cost $120,000, with equipment. C. K. Porter & Sons, 3 West Eagle Street, Buffalo, are architects; the Industrial Planning Co., 80 West Genesee Street, Buffalo, is mechanical engineer.

N. J., Jamestown—The Department of Public Utilities has plans under consideration for the enlargement of the municipal power plant, to double, approximately, the present generating capacity.

N. Y., Kings Park—The State Hospital Commission, Albany, is considering plans for the construction of a power house at the proposed local memorial hospital, to cost approximately $1,000,000. S. W. Jones, Capitol Building, Albany, is state architect.

N. Y., New York—The Frederick Hussey Realty Co., care of George and Edward Blum, 505 Fifth Avenue, architects, will install a steam power plant in its proposed sixteen-story factory to be constructed at 449-59 Seventh Avenue, to cost in excess of $1,000,000.

N. Y., New York—The Merchants' Refrigerating Co., 161 Chambers Street, will commence the construction of a new sixteen-story cold storage plant, 75 x 105 ft., at Varick and North Moore Streets, estimated to cost $425,000. John B. Snook Sons, 52 Vesey Street, are architects.

N. Y., New York—The Railroad Co-Operative Building & Loan Association, George E. Martin, president, 437 Lexington Avenue, will install a boiler, engine and pumping plant in its proposed sixteen-story bank and office building at 441-43 Lexington Avenue, estimated to cost $850,000, for which plans are being prepared by Ludlow & Peabody, 101 Park Avenue, architects.

N. Y., New York—The United States Navy Purchasing Office, South and Whitehall Streets, will purchase at an early date 10,000 boiler gaskets, as called for in N.S.A.F. requisition 555.

N. C., Bethel—The Common Council has issued bonds for $25,000, the proceeds to be used for a municipal electric plant and system.

N. C., Charlotte—Armour & Co., Union Stock Yards, Chicago, Ill., plan for the installation of an ice-manufacturing and refrigerating plant at their local meat packing house, to be extended and improved. J. F. Thurlong, Jr., is district superintendent.

N. C., Troy—The Deep River Power & Light Co., formerly operating as the Moncure Mfg. Co., Moncure, N. C., has tentative plans under advisement for extensions in its power station, including additional equipment. The company has recently increased its capital to $1,000,000 from $200,000, for expansion.

N. D., Grand Forks—The Common Council is considering tentative plans for the construction of a municipal electric power plant, estimated to cost $120,000. Charles E. Evanson, city clerk.

Ohio, Cincinnati—The Columbia Gas & Electric Co., is perfecting plans to commence work early in the spring on its proposed generating plant on the Big Miami River, estimated to cost $18,000,000. It will be known as the Fort Miami power station.

Ohio, Findlay—The Fostoria Ice & Coal Co., Fostoria, Ohio, has plans under way for the erection of a new local ice-manufacturing plant, estimated to cost $55,000. K. B. Clore is in charge.

Ohio, Portsmouth—The Chesapeake & Ohio Railroad Co., plans for the installation of electric pumping equipment at its proposed water plant at South Portsmouth, estimated to cost $27,000.

Ohio, Toledo—The National Ice Co., Fifth and Naughton Streets, Columbus, Ohio, has plans for the construction of a one-story ice-manufacturing plant at Michigan Avenue and Cherry Street, estimated to cost $240,000, including equipment. George Bright, 103 Marquette Building, Detroit, Mich., is engineer.

Okla., Apperson—The Common Council plans for the installation of electric-operated pumping machinery in connection with its proposed waterworks, for which a fund of $75,000 is available.

Okla., Nowata—The Common Council plans for the installation of electric-operated pumping machinery at the waterworks, in connection with extensions to cost about $75,000. Oscar Dobbs is city manager.

Okla., Tulsa—The Oklahoma Union Railway Co., plans for the installation of an oil-operated power plant at its proposed local interurban station, to cost in excess of $500,000.

Pa., Philadelphia—The Board of Trustees, University of Pennsylvania, Thirty-fourth Street, is having plans completed for its proposed steam-operated power plant on the Schuylkill River, to replace the present station at Spruce and Thirty-fourth Streets. McClellan & Junkersfeld, 45 William Street, New York, N. Y., are engineers.

Pa., Wilsonville — The Pennsylvania Power & Light Corporation, Allentown, Pa., has secured permission from the State Water & Power Resources Board, to construct and operate a hydro-electric power plant on Wallenpaupack Creek, in this section. The reported cost is placed at $750,000.

S. C., Hartsville—The Common Council will receive bids until Feb. 27, for a centrifugal pump, with capacity of 1,000 g.p.m., and auxiliary equipment and connections, for a new waterworks station. The Ryan Engineering Co., Arcade Building, Columbia, S. C., is engineer.

S. C., Latta—The Common Council plans for the installation of electric-pumping equipment in connection with a waterworks system to cost $33,000, for which bonds have been approved.

Tenn., Coal Creek—The Common Council plans for the installation of an electric-operated pumping plant in connection with a municipal waterworks, for which bonds for $30,000, are being sold.

Tenn., Knoxville—The Broadway Market & Auditorium Co., plans for the construction of a cold storage and refrigerating plant at its proposed local market, estimated to cost about $225,000. J. L. Humphreys is president and general manager.

Tenn., Knoxville—The Miller Lumber Co., Knoxville, plans for the construction of a steam power plant on 120-acre tract of timberland in Loudon County, recently acquired, in connection with a saw mill and lumber plant. Marion J. Miller is head.

Tex., Frost—The Frost Oil Mill, Joseph C. Keitt, manager, will commence the construction of a local artificial ice-manufacturing plant, estimated to cost $37,000. It is expected to use oil-operated engines.

Tex., Haskell—The Western Cotton Oil Co., will build a power house at its proposed local cottonseed oil mill, estimated to cost close to $100,000. It is expected to call for equipment bids early in Feb. Earl Cogdell is general manager.

Tex., McAllen—The Rio Grande Valley Electric & Ice Co., plans for the installation of an electric-operated pumping plant in connection with extensions in the local waterworks.

Tex., Malone—The Town Council plans for the installation of electric-operated pumping machinery in connection with waterworks extensions, estimated to cost $40,000, for which bonds have been voted.

Tex., Mart—The Common Council plans for the installation of electric-operated pumping machinery at the proposed municipal waterworks, for which bonds for $150,000 have been voted.

Tex., Ranger—The City Council plans for the installation of electric-operated pumping machinery and auxiliary equipment in connection with extensions and betterments in the municipal waterworks, for which bonds for $150,000 have been approved.

Tex., Snyder—The Snyder Utilities Co., is planning for the rebuilding of the portion of its power plant and ice-manufacturing plant, adjoining, destroyed by fire, Jan. 19, with loss of about $35,000. D. P. Yoder is president.

Tex., Trenton—The Town Council is considering the installation of electric-operated pumping machinery in connection with a municipal waterworks.

Va., Danville—The Department of Public Utilities is planning for the installation of electric-operated pumping machinery in connection with extensions and improvements in the municipal waterworks.

Va., Petersburg—The Stockdell-Myers Hardware Co., South Sycamore Street, is planning for the purchase of a 150 hp. return tubular boiler, 100 hp. engine, and auxiliary equipment.

Va., Richmond—The Clay Products Co., W. L. Riggleman, secretary, plans for the construction of a power house at its proposed brick manufacturing plant near the city limits, estimated to cost $110,000. It is expected to use oil fuel.

Va., Richmond—The Russell S. Myers Co., 1209 East Broad Street, general contractor, is planning for the purchase of a boiler, air compressor and other power equipment.

Wash., Lynden—The Common Council plans for the installation of electric-operated pumping machinery in connection with a proposed municipal water plant.

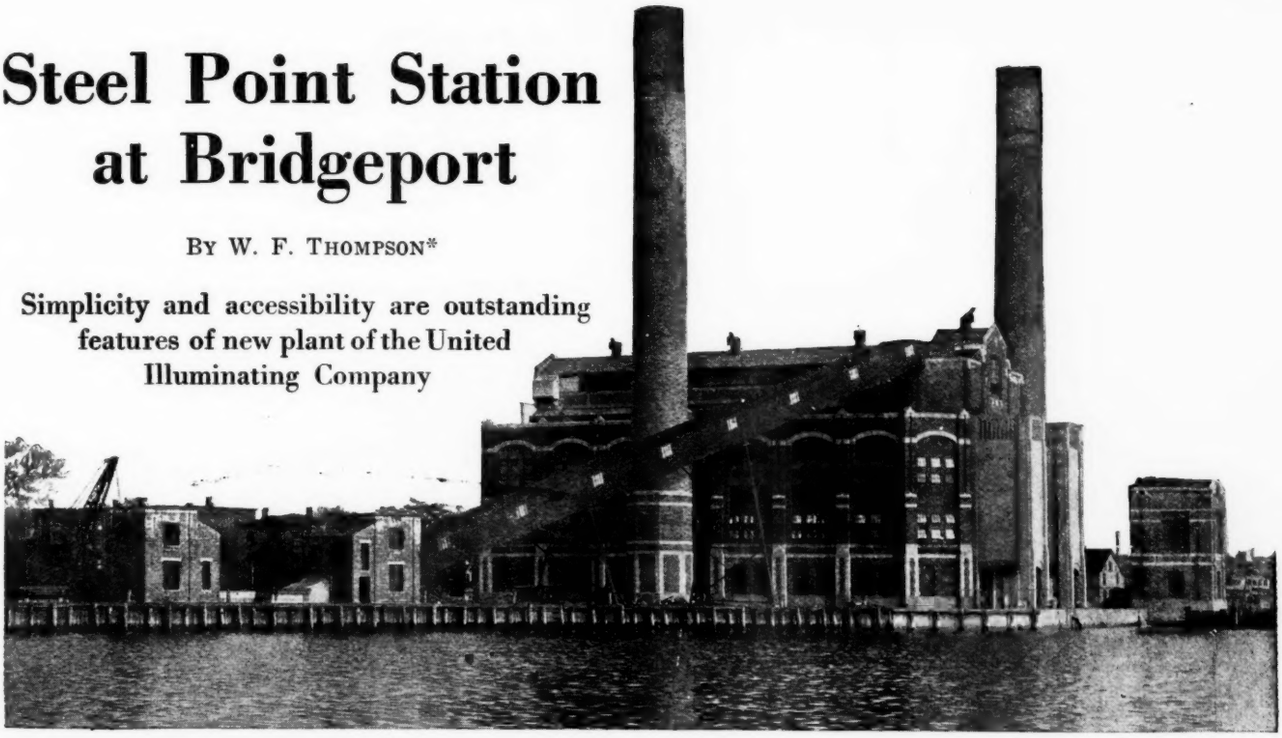
Wash., Seattle—The Puget Sound Power & Light Co., has made application to the state department for permission to construct and operate a hydro-electric power plant on the Baker River, with total capacity of 65,000 hp., estimated to cost $3,500,000. The company is operated by the Stone & Webster Management Corporation, 147 Milk Street, Boston, Mass.

Wash., Westport—The Superintendent of Lighthouses Portland, Ore., will take bids at once for the construction of a power house at the local Grays Harbor Light Station.

Steel Point Station at Bridgeport

By W. F. Thompson*

Simplicity and accessibility are outstanding features of new plant of the United Illuminating Company



THE United Illuminating Company, of Bridgeport, Connecticut, realizing that the economical limit of expansion had been reached at its Congress Street Station, decided that a new generating plant was necessary in order to keep pace with the ever-increasing load.

The demand for electrical energy in Bridgeport, particularly for industrial purposes, has been growing at a phenomenal rate. During the war the growth was attributed to many war industries in that locality. With the cessation of the war and the closing of those special industries it was expected that the rate of increase would slow up. This expectation was, however, never realized, for even during the dull period the load kept on climbing. Hence, the necessity for an ample, as well as a reliable, power supply for the future.

The site selected for the plant is directly on the open harbor leading into Long Island Sound. The location is central with respect to load distribution and yet retains the advantages of deep water which readily admits large ocean-going coal carriers. The property is approximately 8½ acres in size, which, with all the other advantages, lends itself to an unlimited future development. This location was chosen (1) to secure an adequate and clean supply of condenser cooling water, (2) to facilitate the receipt of coal shipments by water, (3) to allow ample room for expansion, (4) to provide adequate coal-handling and storing facilities, as well as to permit the disposal of ashes, either by motor truck or barge. The plant was designed to be attractive, harmonious and an asset to the community.

The present completed section of the plant consists of three 10,000-kw. generating units and six batteries of boilers, totaling 15,092 sq.ft. each. Plans have already been completed and construction started on the first extension to this new plant, which, when completed, will double the present generating capacity.

The architecture of the structure is Gothic. The exterior is constructed of dark red brick, with white artificial stone trim. Structural steel and brick, with reinforced-concrete floors and composition roofing are used. The north walls, being temporary to permit of plant extensions, are constructed of tile. The three sections of the building consist of the boiler room, turbine room and switchhouse.

An ultimate station capacity of approximately 100,000 kw. or more, depending on the size of the units installed, can be obtained by expansion toward the north. The property extends north and west from the south end of East Main Street, upon which the frontage is approximately 620 ft., leaving a considerable margin over the length of the ultimate future plant.

The Steel Point site has a harbor frontage on the south and west amounting to more than 1,000 ft. Part of this is shown in Fig. 1. This gives more than enough room for circulating-water connections and also coal and ash barges. Advantage may also be taken of the harbor frontage to simplify the shipping and handling of heavy equipment.

By referring again to Fig. 1, it will be noticed how the station is laid out with respect to the sea wall, coal- and ash-handling equipment and general method of future development. The coal will enter at the west side of the plant, and the current generated will leave on the east side. Thus, a conversion of energy in the form of a straight line is made possible from coal pile to buses.

It will be noticed by referring to Fig. 2, which shows a general cross-section of the station, that the foundation mats are placed at one common elevation and are of substantially uniform design. The foundation of each main unit is separate from all other foundations and floors, so as to minimize and localize vibration. In order to keep all equipment above high tide, excavated basements have been eliminated. The ground floor, which is a little above extreme high water,

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